CTPS TECHNICAL REPORT 61

I-93/ROUTE 16 INTERCHANGE REEVALUATION

August 1987

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TITLE I-93/Route 16 Interchange Reevaluation

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ABSTRACT Traffic volumes in the area of the I-93/Route 16 interchange for base-year 1987 and future-year 2010 have been developed and analyzed using methods comparable to those used in the 1980 Massachusetts Department of Public Works FONSI report. Current (1987) traffic volumes in the interchange area were found to exceed FONSI future-year (2000) estimates in several instances.

Analysis of existing levels of service in Medford Square indicates that construction of the adjacent Ring Road has improved traffic conditions throughout the Square. The proposed interchange improvements are projected to attract traffic at rates similar to those forecast in the FONSI report. The diversion of this traffic from Medford Square during the AM and PM peak hours would be expected to cause further improvement in levels of service.

This document was prepared by **CENTRAL TRANSPORTATION PLANNING STAFF**, an interagency transportation planning staff created and directed by the Metropolitan Planning Organization, consisting of the member agencies.

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1 INTRODUCTION

1.1 BACKGROUND

In 1980, the Massachusetts Department of Public Works (MDPW) released a "Finding of No Significant Impact" (FONSI) report documenting the long-term effects of proposed improvements to the I-93/Route 16 Interchange in Medford, Massachusetts.

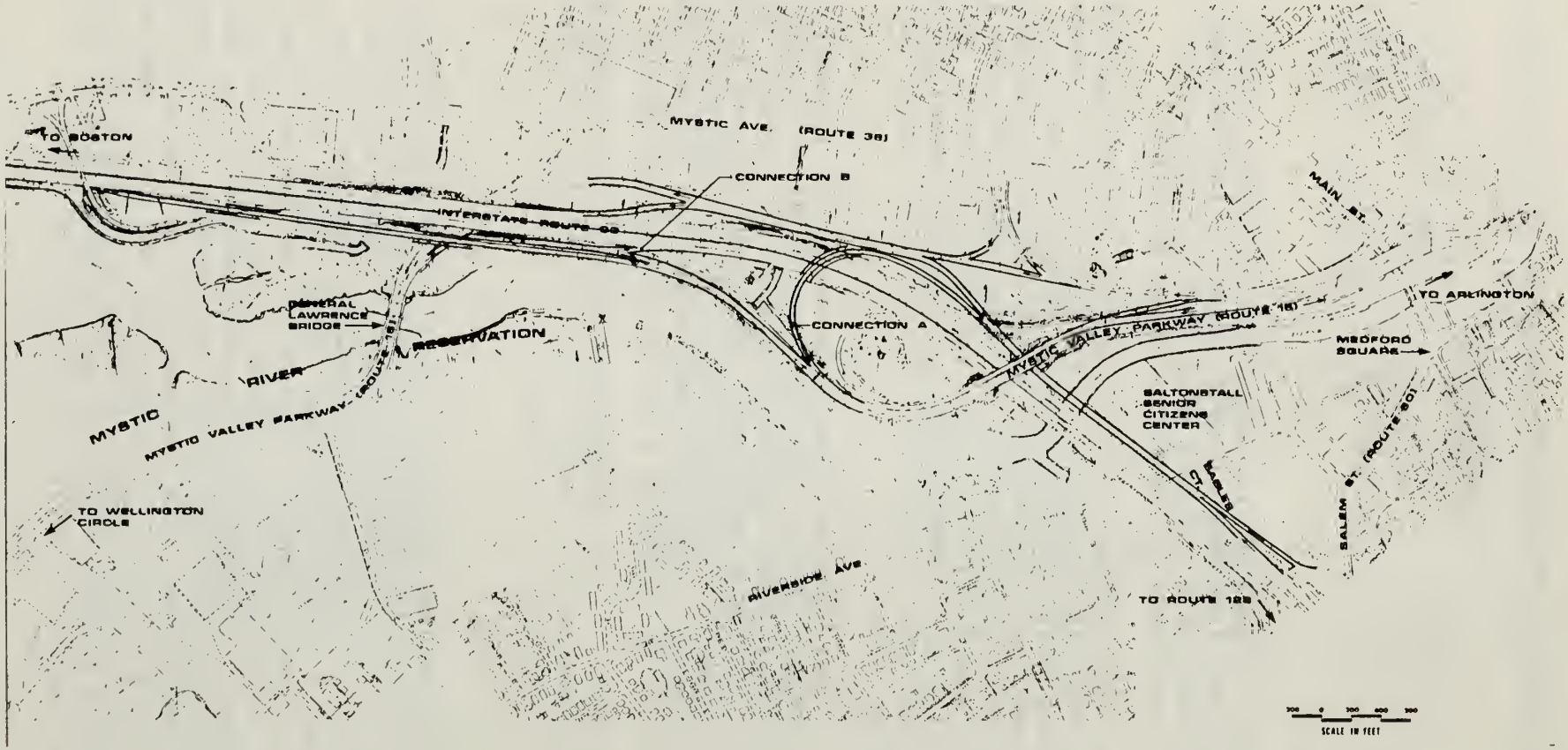
As proposed, the project would provide improved access between I-93 and Route 16 through the construction of two new ramp connections at the existing interchange of the two roadways. One connection (Connection "A") would provide direct access from southbound I-93 to westbound Route 16. The second connection (Connection "B") would directly link westbound Route 16 to northbound I-93. During the construction process all existing ramps would be maintained and upgraded to improve the overall safety of vehicle operations.

A total of three alternatives were evaluated as part of the FONSI work, a no-build option and two construction alternatives. Each of the two construction alternatives would require some property acquisition although most work would be confined to the existing right-of-way. The FONSI report cites engineering, economic and environmental considerations among the factors leading to the selection of Alternative 1 as the preferred option.

The Alternative 1 (the "Selected Alternative") Connections "A" and "B" are located on a map of the I-93/Route 16 interchange area in Figure 1-1.

1.2 PURPOSE

The interchange improvements available through implementation of the Selected Alternative as describe in the FONSI Report included greater safety and better levels of service on local streets particularly those in Medford Square. Under current or no-build conditions, the I-93 to Route 16 west movement is generally made from the I-93/Route 60 interchange through Medford Square, Salem and Main streets to the Route 16/Main Street interchange. This Medford Square connection is used to access Route 16 west from I-93 north, because no interchange connection presently exists. The absence of this connection has come to be referred to as the missing link by local residents. As presented in the FONSI Report, the construction of proposed Connection A would create this link and would effect a reduction in the need for through traffic to use Medford Square.

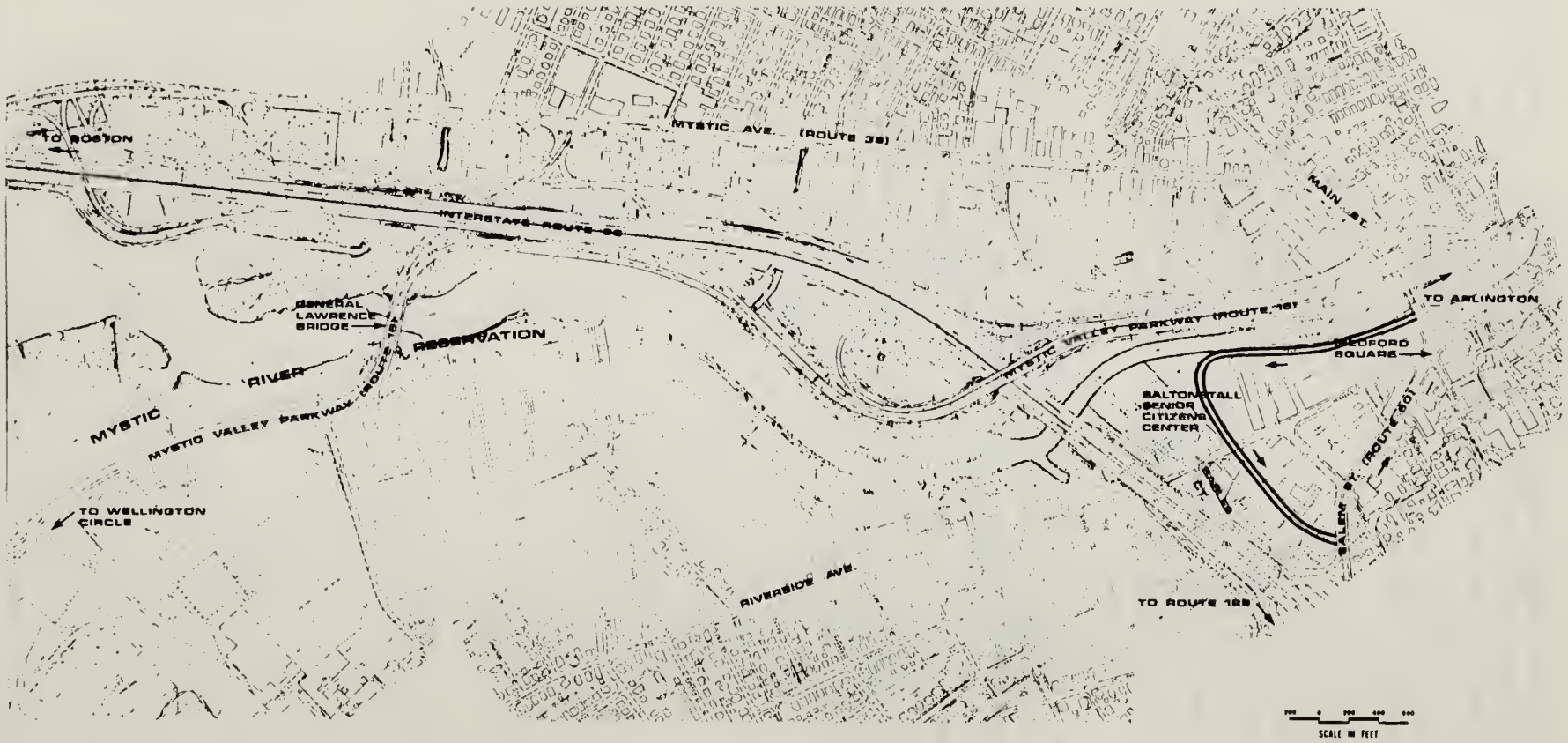


I-93/Route 16 Interchange Reevaluation Technical Report 61 August 1987	ALTERNATIVE 1 "SELECTED ALTERNATIVE"	CTPS FIGURE 1-1

At the time the FONSI Report was in process, a Medford Square Urban Systems traffic project to create a one-way street system through Medford Square was in the initial stage of preparation (refer to Figure 1-2). In examining alternatives, the FONSI Report assumed the layout of the 1979 street system would be preserved through forecast-year 2000.

The purpose of this effort is, therefore, to re-examine the Selected Alternative from a traffic operations standpoint and determine whether proposed construction would still effect a diversion of through traffic from local streets onto Connections A and B, and thereby, continue to provide improved operational levels of service in the area. No effort is made to identify existing problems for which other corrective actions such as, signal retiming, geometric changes or access restrictions might be appropriate.

Again, the attempt in this re-evaluation is to isolate the traffic diversion effects of the proposed ramp construction on operations at area locations. The locations selected for analysis are essentially those analyzed previously in the FONSI analysis. It is important for the reader to understand that this study is not a study of existing or anticipated future problems, but is a re-evaluation of present and future traffic operations under build and no-build scenarios within the context of the current street network.



I-93/Route 16 Interchange Reevaluation	LOCATION OF MEDFORD SQUARE "RING ROAD" URBAN SYSTEMS IMPROVEMENTS	CTPS
Technical Report 61 August 1987		FIGURE 1-2

2 DATA COLLECTION

2.1 SOCIO-ECONOMIC CHARACTERISTICS

The need to forecast future-year traffic volumes requires as input expected changes in future-year land use and population characteristics that directly influence trip making within the area of concern. For the purpose of producing a travel demand forecast for 1987, 1990 and 2010 in this study, employment and household characteristics were developed as input. Specifically, forecasts of retail and non-retail employment and the number of households by income were prepared for each traffic zone in the study area.

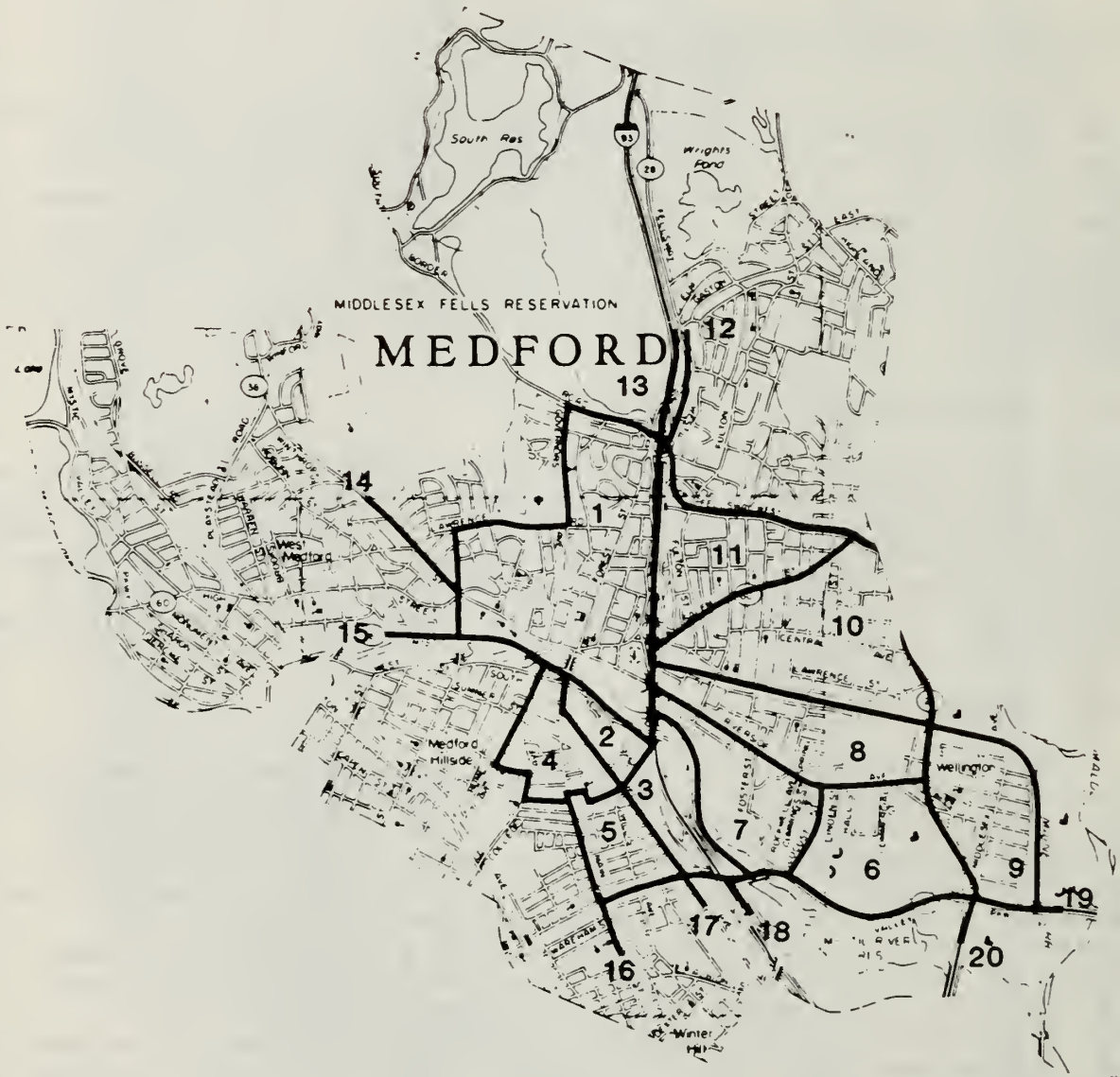
2.1.1 Traffic Zone Definition

The study area was divided into 19 traffic zones as shown on Figure 2-1. The internal zone structure is consistent with the MDPW traffic zone divisions for the town of Medford in that zones 1 through 10 are a further disaggregation of MDPW traffic zones 280-287. External zones 11 through 19 conversely represent an aggregation of MDPW traffic zones and community-level information for the area within 10 miles of Medford Square.

2.1.2 Households by Income

Traffic zone level household by income projections were produced from a combination of 1980 U.S. Census and Metropolitan Area Planning Council (MAPC) sources. The basis for the total number of households forecast is the MAPC traffic-zone level population projections and regional-wide forecast of persons per household. The regional person-per-household factors were applied directly to the zonal population projections to obtain zone-level household estimates. Household incomes were taken from the 1980 U.S. Census community-level estimates. For modeling purposes, 1980 constant dollars was assumed throughout the forecast period. The U.S. Census municipal income figures were, therefore, used uniformly among appropriate traffic zones in the baseline and for each of the future-year projections. A summary of study area household characteristics is presented by forecast year in Appendix A.

The household forecasts produced indicate that very little change in households in the internal study area is expected between 1987 and the 1990 and 2010 horizon years. This is reflective of anticipated declines in the area's population as the expected number of persons per household also declines.



I-93/Route 16 Interchange Reevaluation	I-93/ROUTE 16 STUDY AREA TRAFFIC ZONE BOUNDARIES	CTPS
Technical Report 61 August 1987		FIGURE 2-1

In the surrounding area, population levels are generally expected to remain stable through 2010. This eventuality will contribute to a slight increase in external area housing totals as regional levels of persons per household declines in the future.

2.1.3 Employment

Projections of baseline (1987) and future-year total employment were obtained directly from MAPC. Retail sector forecasts, largely unavailable, were developed independently. The "Gompertz Model" forecasting tool cited in NCHRP report #266 Forecasting Inputs to Transportation Planning was used exclusively to project future-year retail sector employment. Once retail forecasts were produced, non-retail employment could be determined directly.

The forecast of retail sector employment with the Gompertz model is a data-intensive task. Historic data is the only input necessary to use the Gompertz Model, however, sufficient data is necessary to establish long-term trends. The underlying assumption of the Gompertz Model is that geometric growth will reach, or has already reached, a level beyond which growth will begin to slow.

Graphically one of four possible curvelinear plots of data (retail employment) over time will result from fitting historic data to a Gompertz Model; an increasing or decreasing S-shaped curve and an increasing or decreasing geometric curve. To establish historic trends in retail employment in Medford and the surrounding communities, Division of Employment Security (DES) reported retail employment figures dating from 1959 through 1985 were used. These data were used for all forecasts unless it was clear from a visual inspection of the data that trends had, in fact, been reversed during the 25-year period. For these exceptions the data used began with the first year of the trend reversal The resulting retail and non-retail employment totals for the study area are also summarized in Appendix A.

In general, the study area employment outlook is similar to forecast growth in households. The internal area, that within Medford, is expected to experience only marginal increases in retail and non-retail employment sectors through 2010. This is indicative of the late stage of development the city is presently in and anticipation that future development will essentially be a replacement of existing industry.

In the surrounding external area employment is expected to increase more rapidly than internally. Here, growth in retail employment is projected to occur more rapidly than growth in the non-retail sector through 2010.

2.2 TRAFFIC VOLUMES

To aid in the establishment of a baseline traffic condition, 48-hour directional traffic counts and peak period turning movement vehicle counts were taken at several study area locations early in 1987. In total, 50 count stations in the study area were identified for inclusion in the traffic count survey. Staff and hardware limitations required that the study area be divided in half so that those turning movement counts and directional counts in close proximity could be taken together. These count stations are located in Figure 2-2 and separated into groups in Table 2-1.

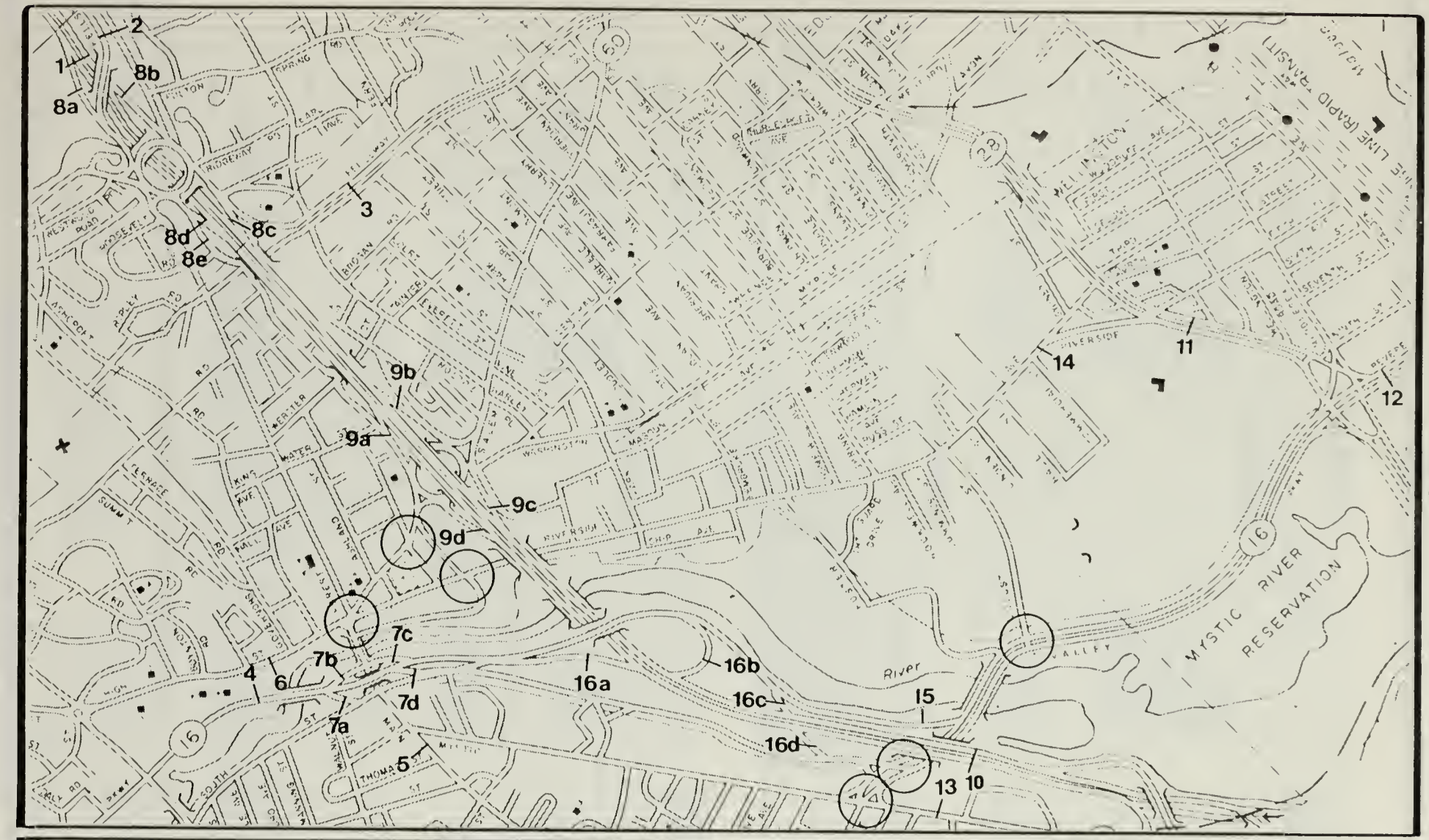
Study area traffic counts were collected during January and February of 1987. All counts collected (turning movements and directional) were summarized to determine AM and PM peak hour volumes. Twenty-four hour summaries were also compiled for each of the directional count locations.

As inputs to the traffic modeling process, AM and PM peak hour counts were adjusted to correct for seasonal variation and day-of-the-week effects. To make these adjustments, MDPW control station count information for I-93 and Route 16 was obtained. Once these effects were corrected, the counts were equilibrated or "balanced" to remove the effects which exist due to survey error and vehicles entering and leaving mid-block.

To establish a uniform AM and PM peak hour for the study area the results of the turning movement count survey were examined. According to the field data, study area peak hour flows principally occur between 7:30 and 8:30 AM and again between 4:30 and 5:30 PM. Certain locations, however, do not conform to this general phenomenon and peak at different times. In addition, the MDPW reports directional volume counts by the hour on the hour. To adjust all volumes to uniform peak hour levels, factors were developed from representative intersection count reports.

For the AM peak hour, the Main Street at Ring Road intersection was selected. The counts indicated that 8:00 to 9:00 AM volumes were 3.06 percent below the 7:30 to 8:30 AM levels. For the PM peak hour volumes at the Mystic Valley Parkway/Locust Street intersection were evaluated and it was found that 5:00 to 6:00 PM volumes were 3.41 percent below peak 4:30 to 5:30 PM levels. These two factors were applied where necessary throughout the study area, to bring recorded volumes to the uniform peak hour times.

As mentioned earlier, further adjustment is generally necessary to correct for seasonal and day-of-the-week variational effects. This correction permits the traffic simulation to be calibrated to average annualized weekday traffic (AAWDT) volume conditions and for the same to be forecast.



I-93/Route 16 Interchange Reevaluation	TRAFFIC COUNT STATION LOCATIONS	CTPS
Technical Report 61 August 1987		FIGURE 2-2

GROUP 1

Station Number	Roadway	Location
	Road Segments	
1	I-93	North of Roosevelt Circle
2	Route 28	North of Roosevelt Circle
3	Route 28	East of Fulton Street
4	Route 16	East of Winthrop Street
5	Main Street	South of Mystic Avenue
6	High Street	East of Winthrop Street
	Ramps	
7	Route 16	at Main Street
8	I-93	at Roosevelt Circle
9	I-93	at Route 60
	Intersections	
	Medford Square-Main St. at Salem St., High St. and Forest St.	
	Main Street at Ring Road	
	Ring Road at Riverside Street	
	Ring Road at Salem Street	
	Riverside Street at Salem Street	

GROUP 2

Station Number	Roadway	Location
	Road Segments	
10	I-93	South of Route 16
11	Route 28	South of Riverside Street
12	Route 16	East of Route 28, West of Wellington Station
13	Mystic Avenue (Rt 38)	South of Mystic Valley Parkway
14	Riverside Street	West of Route 28 (Fellsway)
15	Mystic Valley Parkway (NB)	See Map
	Ramps	
16	I-93	at Route 16
	Intersections	
	Mystic Valley Parkway (Route 16) at Locust Street	
	Mystic Valley Parkway (Eastbound) at Medford Veterans Parkway	
	Mystic Road (Route 38) at Medford Veterans parkway	

For these purposes, day-of-the-week and month-of-the-year factors were developed from MDPW control station count data. To adjust the Route I-93 throughway and ramp count data, MDPW Control Station 8100 (I-93 at Southampton Street, Boston) was used. For data collected elsewhere in the study area the MDPW Control Station 82100 (Route 16, east of Wellington Circle) information was used to prepare the AAWDT estimates. The factors derived from the control station data are presented in Table 2-2. As expected, the information in the Table shows that very little adjustment is necessary to bring Tuesday, Wednesday or Thursday volumes to average weekday levels. However, as also indicated in the adjustment factors, January and February traffic volumes roughly represent only about 90 percent of the annual daily average volume levels. These factors were applied to all AM and PM peak hour count data and 24-hour volume totals as appropriate to generate equivalent AAWDT volumes throughout the study area.

As noted above, the traffic count data collected were both manual turning-movement counts and ATR directional counts. Because the data was collected during different time periods and by differing means, there were minor inconsistencies among the reported volumes at adjacent count stations. The presence of this error within the data necessitated a further and final refinement of the AAWDT count information before it could be used for the intended purpose of calibrating the synthetic volume assignments produced from the modeling process.

To eliminate these inconsistencies, a procedure commonly referred to as traffic-count balancing was used which reconciles mathematically the inconsistencies within reported volumes by solving a series of simultaneous equations; the variables of which are reported counts. In this procedure, all reported count data are assumed to be equally valid and are adjusted to reflect the influence of all related count information. In those instances where the differences in reported link volumes are significant and expected, due to the presence of mid-block features such as, parking garages or major shopping facilities, these features are represented as individual traffic zones where traffic can be loaded onto and removed from the highway system.

The "balanced" counts which result from this process are consistent within intersections and between adjacent highway links unless a traffic zone has been connected to the network between a link pair. That is, all intersection turning movements sum to consistent entering and exiting totals, and directional link volumes at end points are equivalent. Where traffic zones are connected to the network, the expected differences in traffic volumes are preserved to the extent that permits balancing on the remainder of the network. Selected 1987 AM and PM peak hour AAWDT volumes are posted on Figures 2-3 and 2-4.

STATION 82100 - ROUTE 16, EAST OF ROUTE 16/ROUTE 28 JUNCTION*

Day-of-the-Week

	January	February
Tuesday	1.0335	N/A
Wednesday	N/A	1.0222
Thursday	0.9674	0.9898

Month-of-the-Year

January	1.0229
February	1.0714

STATION 8100 - I-93, AT SOUTHAMPTON STREET, BOSTON**

Day-of-the-Week

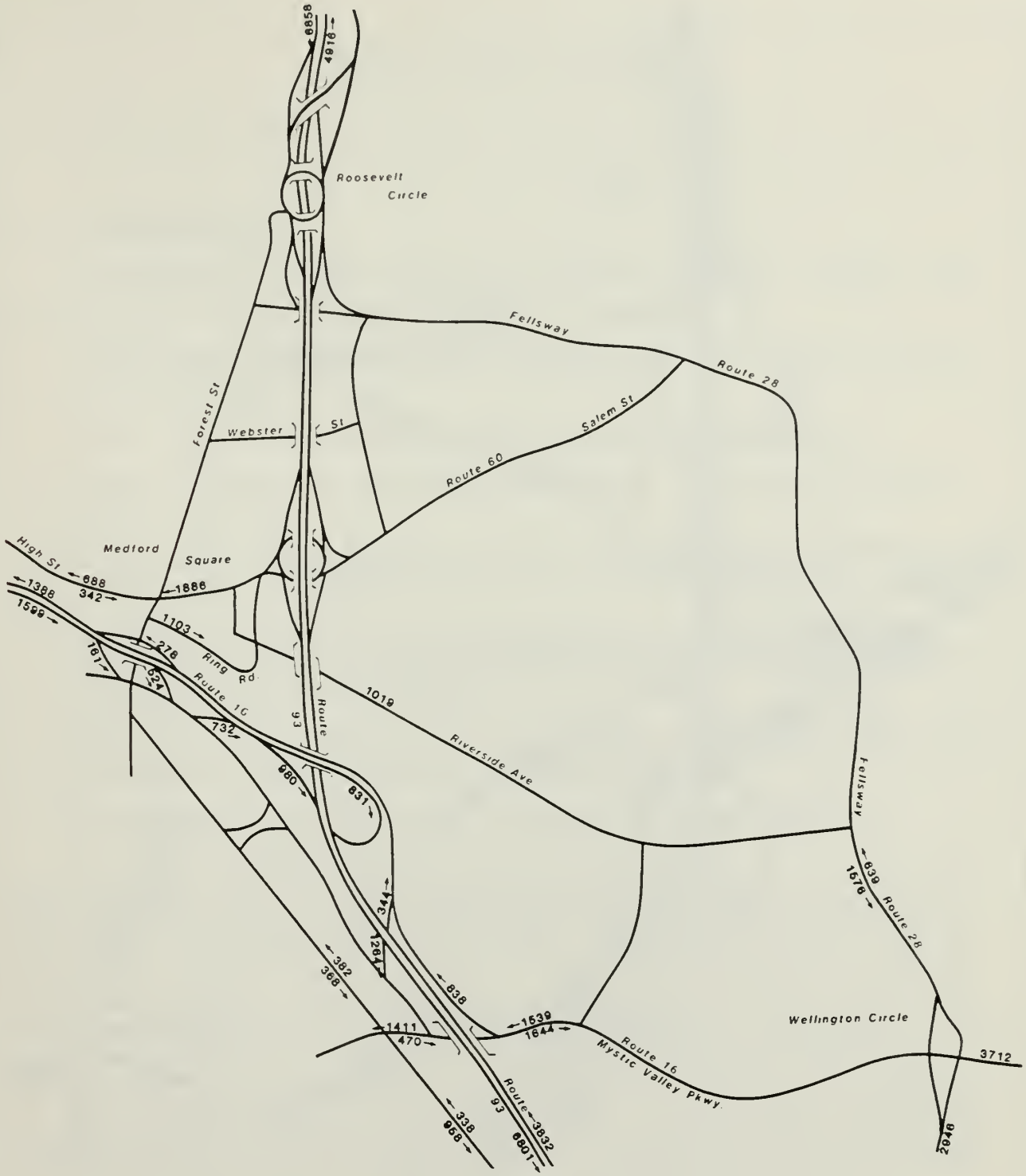
	January	February
Tuesday	1.0089	1.0082
Wednesday	0.9885	0.9356
Thursday	1.0261	1.0020

Month-of-the-Year

January	1.1049
February	1.1006

*For state-numbered route and local intersection count data.

**For I-93 mainline and ramp count data.



All Numbers listed with no arrows are TWO Directional Volumes

I-93/Route 16 Interchange Reevaluation	SELECTED 1987 AM PEAK HOUR AAWDT COUNT VOLUMES	CTPS
Technical Report 61 August 1987		FIGURE 2-3

I-93/Route 16 Interchange Reevaluation Technical Report 61 August 1987	SELECTED 1987 PM PEAK HOUR AAWDT COUNT VOLUMES	CTPS FIGURE 2-4

3 TRAVEL DEMAND FORECASTS

3.1 INTRODUCTION

Procedurally, 1987 AM, PM and 24-hour traffic volumes were synthetically derived as follows:

- Trips were generated from household and employment characteristics.
- Trips were distributed by gravity model application.
- Travel times were estimated according to Moore's shortest path algorithm.
- Trip tables were assigned using a capacity restraint traffic assignment procedure.
- Base-year 1987 traffic assignments were calibrated using balanced counts to constrain the Willumsen, Van Zuylen trip table estimation procedure.
- Network characteristics were modified as necessary to eliminate assignment and count inconsistencies.
- Calibrated trip table was assigned to final networks.

This particular set of steps were followed so that future-year 1990 and 2010 travel demand scenarios could be generated directly from changes in socioeconomic characteristics, and to determine a relationship between the gravity model distributed trip table and the calibrated trip table. The need to identify differences between the baseline gravity-model distributed trip table and the count-calibrated trip table used in the final baseline assignments is of particular importance to this process. Because the source of these differences is traffic count-based, the adjustments made to the socioeconomic trip table represent a more accurate distribution of the trips produced and attracted among specified traffic zones than is possible through reliance on the gravity model process alone. By dividing the count-calibrated table by the gravity-model distributed tables, separate tables of cell adjustment factors were produced which were applied to the appropriate future-year AM, PM and 24-hour gravity model produced trip tables for calibration.

3.2 BASELINE 1987 TRAFFIC ASSIGNMENTS

The calibrated baseline 1987 AM and PM peak hour traffic assignments to the base-case network are presented for selected segments in Figures 3-1 and 3-2. To validate modeled results a comparison of assigned volumes to count volumes was made which indicated approximately a 5 percent (AM) and 11 percent (PM) total root mean square error. This level of error is considered to be extremely good considering the detail attempted in calibrating to individual turning movement counts at major area intersections. Table 3-1 is a comparative list of AM and PM peak hour assignment volumes for a representative sample of network road segments. Clearly, the comparison shown in Table 3-1 indicates an acceptable match among assigned volumes and count data. This is indication that the network as specified is capable of producing accurate assignments.

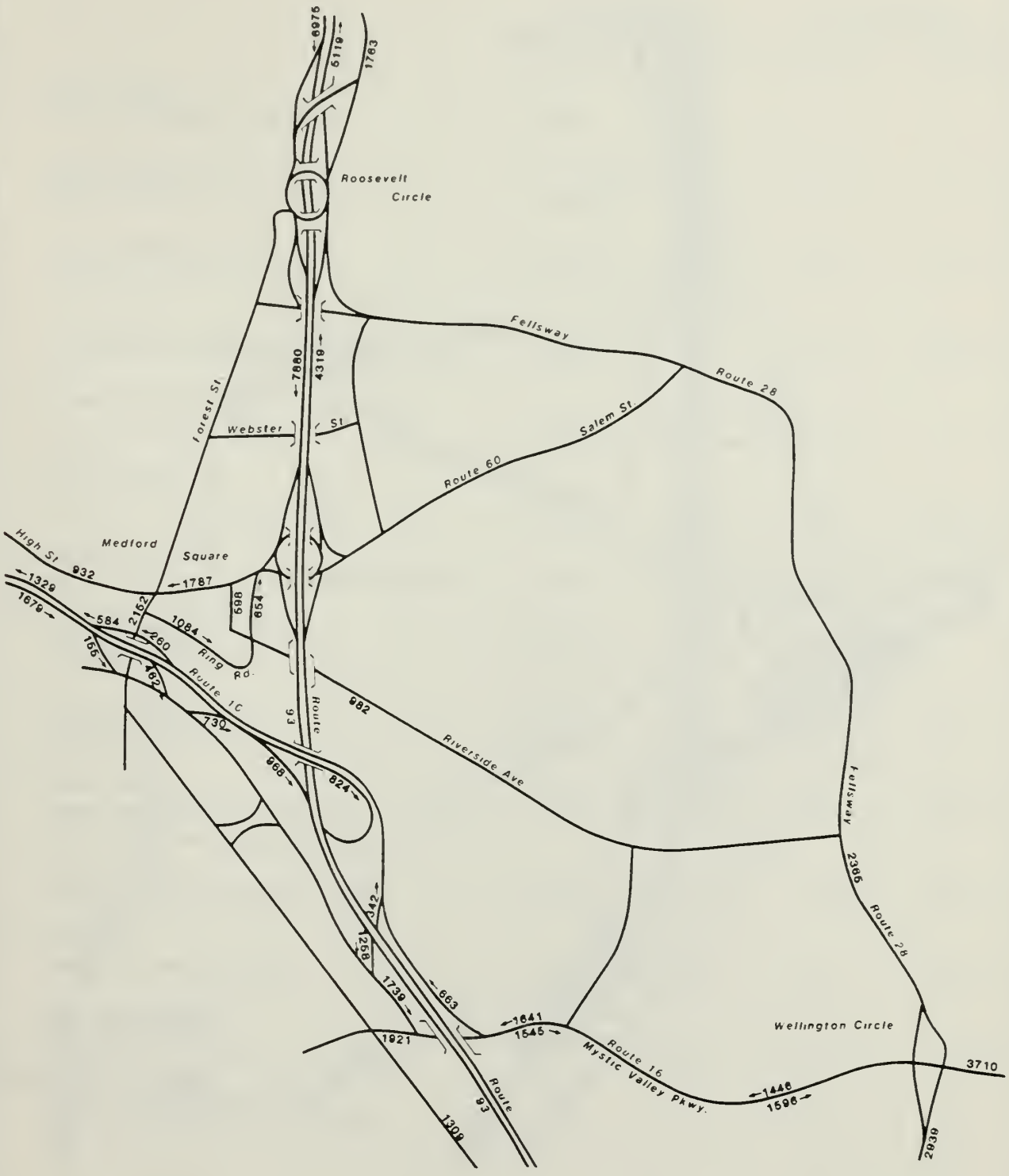
3.3 BASE CASE 1990 AND 2010 ASSIGNMENTS

In order to examine the degree to which the "build project" selected alternative would have anticipated effects on traffic patterns and level of service in and around Medford Square a comparative analysis of build and no-build options was prepared. The representation of the no-build option is the base case network discussed above for which 1987 AAWDT assignments were produced and validated. This base case "no build" network differs from the FONSI report in that it includes all highway network changes that have been made in the study area between 1978 and 1987 including the Urban Systems "Ring Road Project" mentioned in the FONSI Report, but not included in that study's no-build scenario. A similar caveat applies to this study. As of this writing, there are no known projects in the study area that are expected to significantly alter study area traffic patterns beyond those under specific consideration here. Therefore, the base-case network used above in the calibration and validation of the baseline assignment was unchanged in the production of future-year no-build assignments.

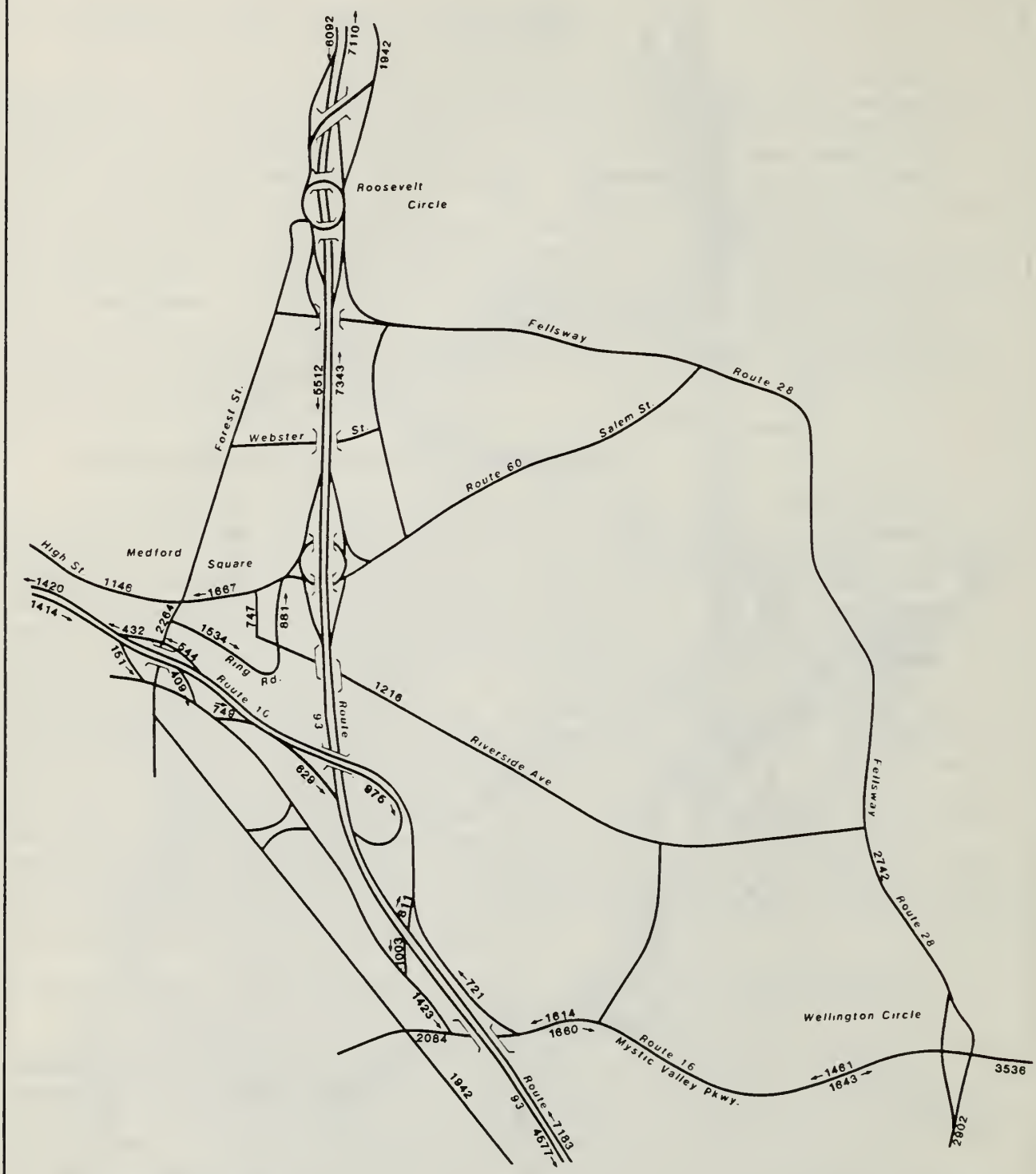
3.4 NO-BUILD ALTERNATIVE 1990 AND 2010 TRAFFIC ASSIGNMENTS

The 1990 and 2010 no-build AM and PM peak hour traffic assignments are presented in Figures 3-3 and 3-4. A visual inspection of the assigned volumes indicates that the morning peak direction of traffic is expected to continue to be oriented southbound on I-93 and westbound on Route 16 west of I-93. Notably, the Medford Square peak direction in the morning is westbound and southbound on Salem Street and Main Street; a trend indicative of the Square's function as a connection between southbound I-93 and westbound Route 16 during this period.

The figures also show that the PM peak hour traffic orientation on Routes 16 and I-93 is the reverse of the AM eastbound and northbound orientation. In Medford Square, the PM peak

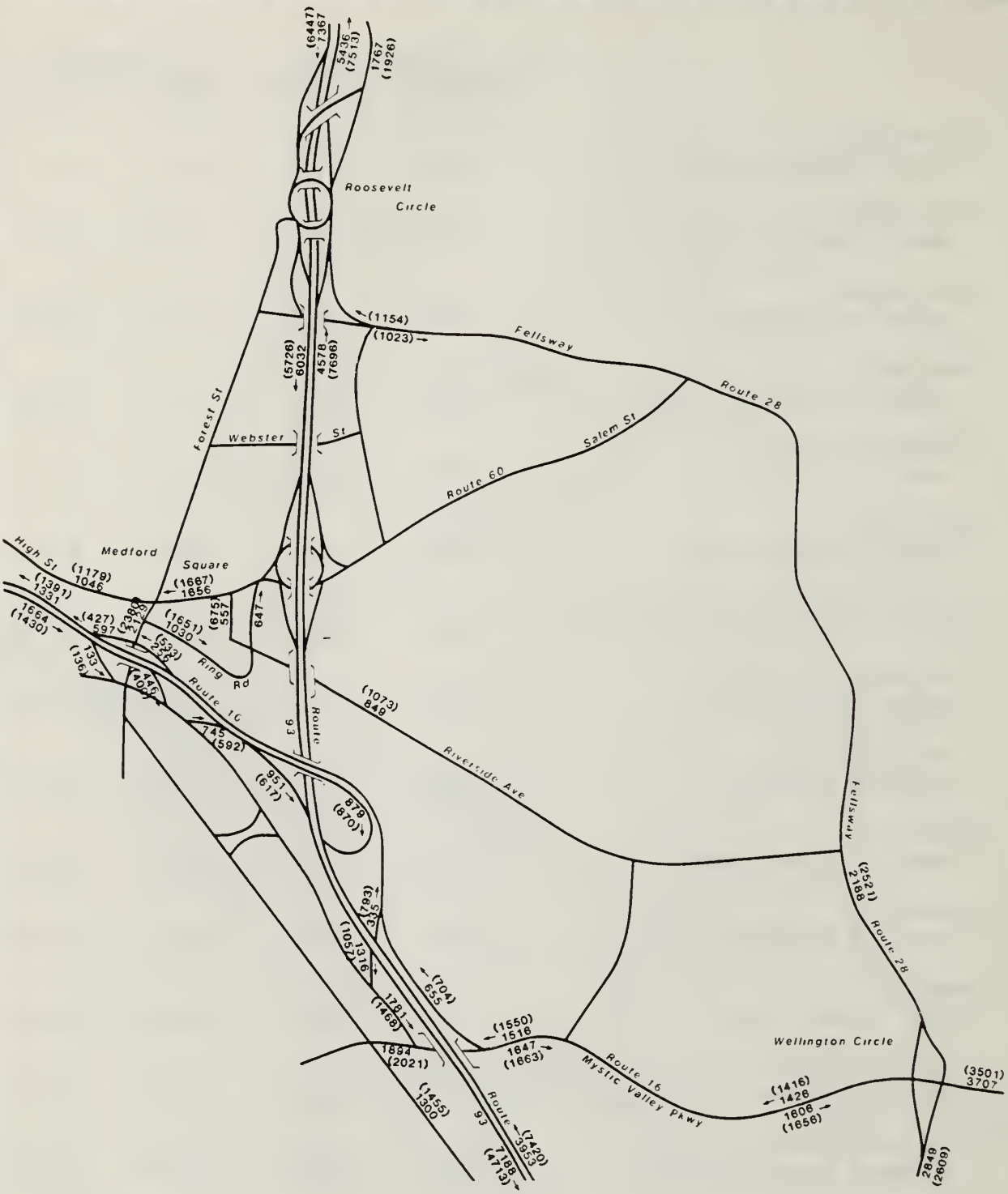


I-93/Route 16 Interchange Reevaluation	1987 AM PEAK HOUR BASELINE ASSIGNMENTS	CTPS
Technical Report 61 August 1987		FIGURE 3-1



I-93/Route 16 Interchange Reevaluation	1987 PM PEAK HOUR BASELINE ASSIGNMENTS	CTPS
Technical Report 61 August 1987		FIGURE 3-2

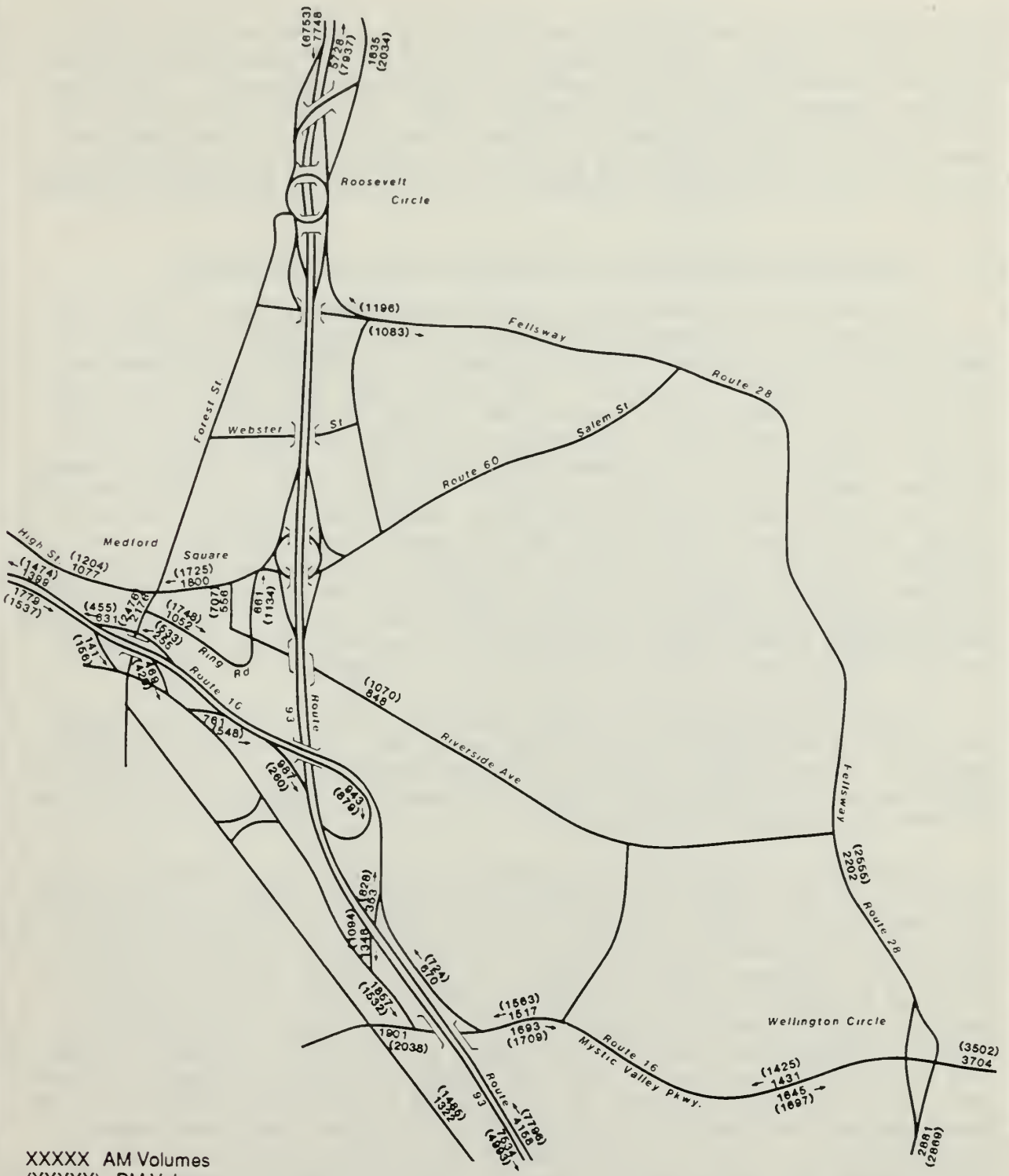
	AM Peak Hour		PM Peak Hour	
	Observed	Assigned	Observed	Assigned
Salem Street East of Medford Square	1,886	1,787	1,631	1,667
High Street West of Medford Square	1,030	982	1,152	1,146
Main Street South of Ring Road	2,230	2,152	2,314	2,264
Ring Road South of Riverside Street	1,103	1,084	1,543	1,534
Riverside Street West of Ring Road	601	598	749	747
Main Street South of Mystic Avenue	1,879	1,861	2,307	2,343
Mystic Avenue South of Medford Veterans Pkwy.	1,296	1,309	1,477	1,474
I-93 Northbound South of Route 16	3,832	3,777	7,911	7,183
I-93 Southbound South of Route 16	6,801	6,973	4,580	4,577
Route 16 East of Locust Street	3,039	3,042	3,108	3,104
Route 28 North of Roosevelt Circle	1,559	1,763	1,836	1,942
Route 16 West of Main Street	2,987	3,008	2,853	2,834
I-93 Northbound North of Roosevelt Circle	4,916	5,119	6,982	7,110
I-93 Southbound North of Roosevelt Circle	6,856	6,975	5,099	6,092



XXXXX AM Volumes
(XXXXX) PM Volumes

All Numbers listed with no Arrows are TWO Directional Volumes

I-93/Route 16 Interchange Reevaluation	1990 AM AND PM PEAK HOUR "NO BUILD" ALTERNATIVE TRAFFIC ASSIGNMENTS	CTPS
Technical Report 61 August 1987		FIGURE 3-3



XXXXX AM Volumes
(XXXXX) PM Volumes

All Numbers listed with no Arrows are TWO Directional Volumes

I-93/Route 16 Interchange Reevaluation	2010 AM AND PM PEAK HOUR "NO BUILD" ALTERNATIVE TRAFFIC ASSIGNMENTS	CTPS
Technical Report 61 August 1987		FIGURE 3-4

direction is not actually the reverse of the AM as the higher Ring Road volumes tend to equal the slightly lower Salem Street volumes resulting in an absence of directional split. This condition suggests that there exists some importance to the I-93 southbound, Medford Square, Route 16 westbound connection and some validity for creating a direct I-93/Route 16 connection due to the fact that Medford Square is not used to make the reverse trip.

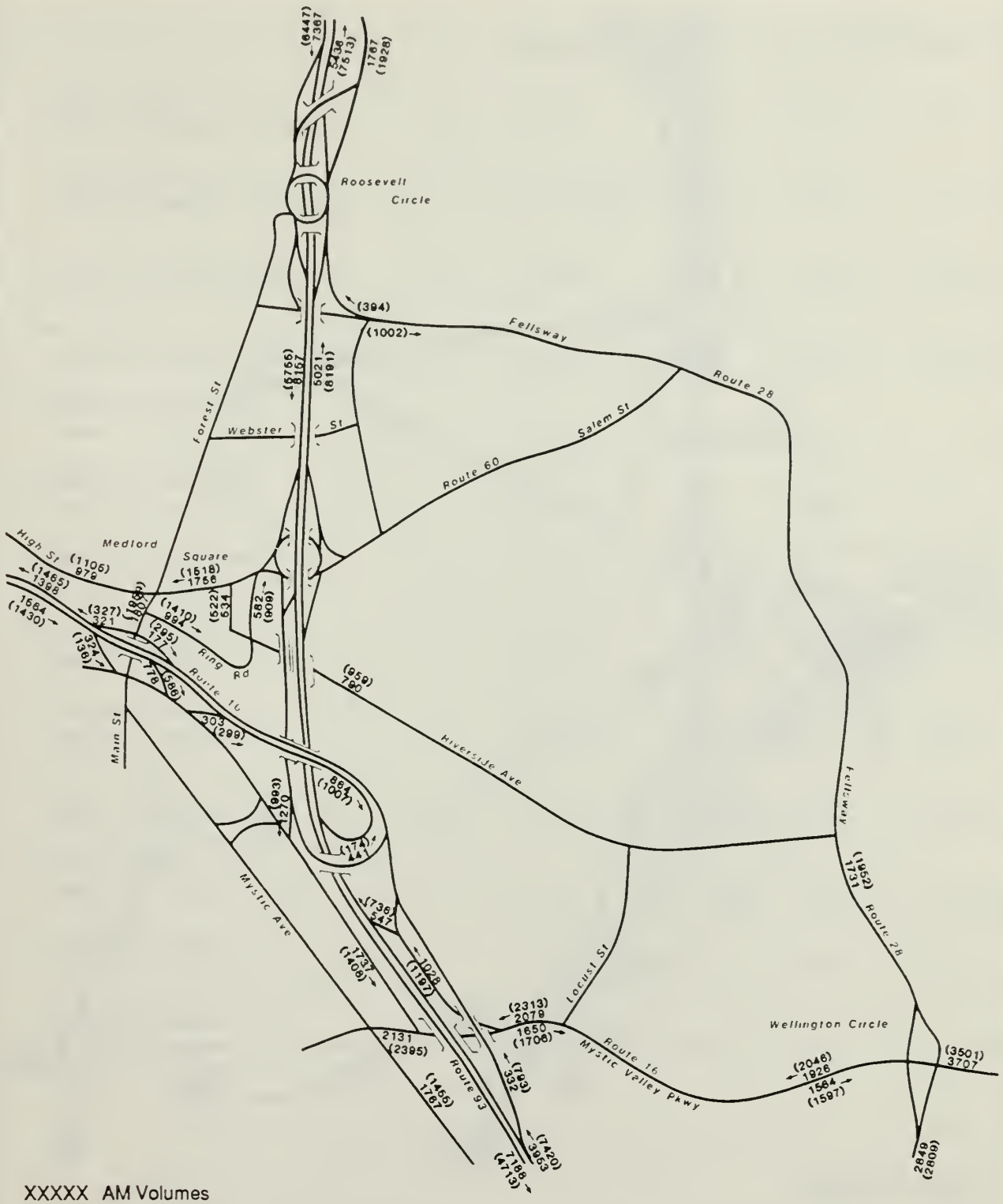
3.5 SELECTED ALTERNATIVE: 1990 AND 2010 ASSIGNMENTS

In order to assess the usage demands associated with the I-93/Route 16 improvement proposal the study area highway network was modified to reflect the changes that would be implemented under the "build" scenario. The final 1990 and 2010 peak hour traffic assignments are posted on the Build Network in Figures 3-5 and 3-6. As shown, the volume totals are not expected to change significantly between 1990 and 2010. This finding again further reflects the socioeconomic forecasts and recognizes that, in the foreseeable future, no major land-use changes are anticipated in the study area that would create significant traffic volume increases. It further indicates that the proposed network changes are not likely to have a significant influence on area travel volume between 1990 and 2010. All 24-hour traffic volume assignments (1987, 1990 and 2010) to the base case and "build" network configurations are presented in Appendix B.

Table 3-2 presents a comparison of 1990 and 2010 no-build and build assignment results for selected links of the highway network. The effect of constructing Connections "A" and "B" on the area are noted in the table by several changes in projected volumes at certain locations.

Beginning with Medford Square, the effect of constructing Connection "A" (Route I-93 south to Route 16 west) is portrayed in lower Salem, High and Main Street volumes, as Salem Street and Main Street presently serve as the most direct route between these two highway links. High Street traffic is only slightly lowered by the volume using it to access Route 16 or other western points originating on I-93 south. The total traffic diverted to Connection "A" is shown as 174 VPH in 1990 and 260 VPH in 2010. The reason for the relatively low volumes is that the I-93 southbound Route 16 westbound directions during the PM peak oppose the major flow directions to the north and east. Consequently, there is lower demand expected during the PM for Connection "A" than during the AM when the demand peaks. The AM peak demands also shown in Table 3-2 indicate hourly Connection "A" volumes of 440 VPH and 469 VPH in 1990 and 2010.

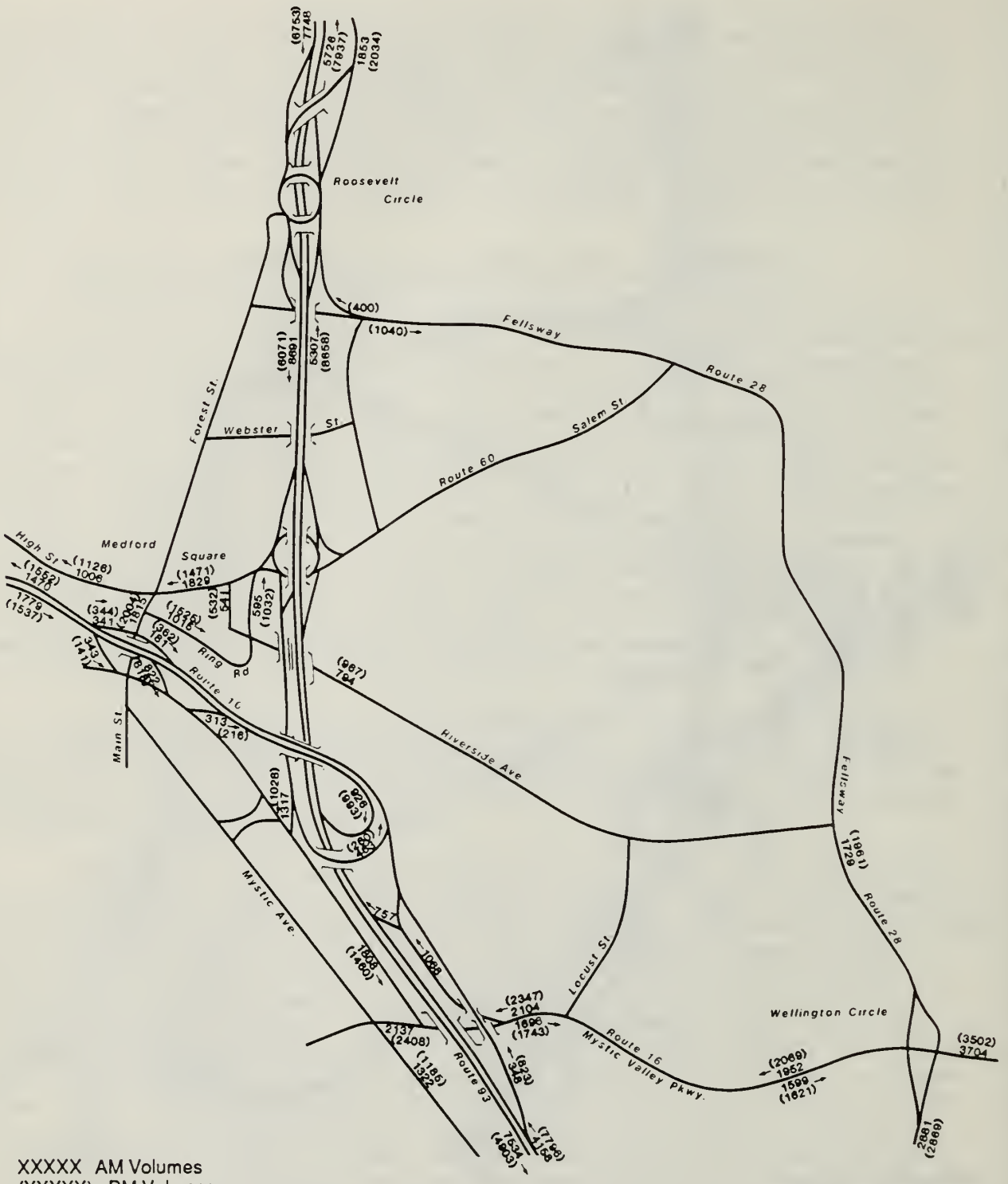
The Connection "B" effects are also evident in Table 3-2. Significantly reduced northbound volumes on Route 28 with additional reductions on the Ring Road and Riverside Street indicate the presence of an area-wide potential for the diversion (from



XXXXX AM Volumes
(XXXXX) PM Volumes

All Numbers listed with no Arrows are TWO Directional Volumes

I-93/Route 16 Interchange Reevaluation	1990 AM AND PM PEAK HOUR "BUILD" ALTERNATIVE TRAFFIC ASSIGNMENTS	CTPS
Technical Report 61 August 1987		FIGURE 3-5



I-93/Route 16 Interchange Reevaluation	2010 AM AND PM PEAK HOUR "BUILD" ALTERNATIVE TRAFFIC ASSIGNMENTS	CTPS
Technical Report 61 August 1987		FIGURE 3-6

	1990		2010	
	No-Build	Build	No-Build	Build
Salem Street East of Medford Square	1,687	1,518	1,725	1,471
High Street West of Medford Square	1,179	1,105	1,204	1,126
Main Street South of Ring Road	2,380	1,959	2,476	2,004
Ring Road South of Riverside Street	1,651	1,410	1,748	1,525
Riverside Street West of Ring Road	675	522	707	532
Route 16 Eastbound West of Main Street	1,430	1,430	1,537	1,537
Route 16 Westbound West of Main Street	1,391	1,465	1,474	1,552
I-93 Northbound South of Route 16	7,420	7,420	7,796	7,796
I-93 Southbound South of Route 16	4,713	4,713	4,933	4,933
Route 16 Eastbound East of Locust Street	1,658	1,597	1,697	1,621
Route 16 Westbound East of Locust Street	1,416	2,046	1,425	2,069
I-93 Northbound South of Route 60 Ramps	7,497	8,371	7,848	8,719
I-93 Southbound South of Route 60 Ramps	5,154	4,151	5,397	4,358

(cont.)

	1990		2010	
	No-Build	Build	No-Build	Build
Route 28 Southbound East of Fulton Street	1,023	1,002	1,083	1,040
Route 28 Northbound East of Fulton Street	1,154	394	1,196	400
Connection "A"	-	174	-	260
		440*		469*
Connection "B"	-	736	-	757
		547*		569*

*AM peak hour

I-93/Route 16 Interchange Reevaluation	COMPARISON OF PEAK-HOUR NO-BUILD AND SELECTED ALTERNATIVE PM-PEAK-HOUR ASSIGNMENTS	CTPS TABLE 3-2b
Technical Report 61 August 1987		

local streets) of trips originating in the southeast quadrant of the study area that are destined to I-93 north in the future. The importance of Connection "B" to service these trips more directly on Route 16 westbound is indicated in the higher volumes on Route 16 in both future forecast years and in the projected hourly ramp volumes of 736 VPH in 1990 and 757 in 2010.

3.6 ASSIGNMENT COMPARISON TO 1990 "FONSI" REPORT

One aspect of this re-evaluation study is to consider the degree to which the 1980 "FONSI" report findings, with respect to traffic, were valid now that the Medford Square Urban Systems "Ring Road" project has been completed. To facilitate this evaluation Table 3-3 has been prepared to highlight the difference between the FONSI AADT forecast and the future-year 2010 forecast of the re-evaluation study.

A cursory review of the locational volumes enumerated in Table 3-3 indicate that the Ring Road project has had and will continue to have a significant effect on traffic volume in the Medford Square area and, that traffic volume, as projected in the current study, is expected to be considerably higher area-wide than that forecast in the FONSI. As mentioned previously, the 2010 traffic forecasts, although increasing over the 20-year 1990-2010 period, are generally not significantly higher than the 1990 volume projections. It is, therefore, clearly the case that the AADT volume projections for the year 2000 made previously were very likely exceeded as early as 1987 and will be exceeded by a relatively large measure in 1990 and 2010.

Another notable difference between the "FONSI" report and re-evaluation study projections are the apparently lower volumes on Riverside Avenue and Salem Street in Medford Square. This apparent discrepancy is the direct result of the creation of a one-way flow system through Medford Square brought about by constructing the Ring Road. Since its completion, the Ring Road has operated in conjunction with Salem Street to provide east-west access. Prior to the construction of the Ring Road, Salem Street carried the total volume of east-west traffic moving between the Square and Route I-93. As shown in Table 3-3, the 2000 AADT on Salem Street assuming the absence of a Ring Road was projected at 2,240 VPH. Considering that Salem Street and the Ring Road will together provide that same function in 2010, the combined no-build volume during the PM peak hour is currently forecast at 3,473 VPH (not shown), a figure significantly higher than the 2,240 peak hour vehicles FONSI-reported volume.

The comparison further indicates that constructing the Selected Alternative will have a similar effect on traffic levels in Medford Square with the Ring Road in place as first projected in the FONSI Report. Again, with reference to the Salem Street volume, the FONSI projected a future-year 2000 change in peak hour volume of -440 VPH. As currently configured, the effect of

Location Description	No-Build 2000 FONSI	No-Build Current 2010	Selected Alternative 2000 FONSI	Selected Alternative Current 2010
Riverside Avenue, between Medford Square and City Hall Avenue	2,180	707	2,180	532
Salem Street, between City Hall Avenue and Medford Square	2,240	1,725	1,800	1,471
Main Street, Medford Square to Route 16 west ramps	2,600	2,476	2,160	2,004
I-93 northbound, north of Route 38 on-ramp	4,830	7,796	4,010	7,796
I-93 southbound, north of Route 38 on-ramp	3,850	4,933	3,850	4,933
I-93 northbound, south of Route 60 off-ramp	4,560	7,848	5,060	8,719
I-93 southbound, south of Route 60 on-ramp	4,000	5,397		
I-93 southbound, south of proposed exit for Connection A			2,640	4,358
Route 16 eastbound, west of Main Street	1,940	1,537	1,940	1,537
Route 16 westbound, west of Main Street	2,260	1,474	2,260	1,552
Route 16, east of I-93 (Gen. Lawrence Bridge)	3,350	3,122	3,760	3,690
Middlesex Fells Parkway, east of I-93 (Fulton St.)	1,630	2,279	1,210	1,440
Connection A			470	469*
Connection B			510	757

I-93/Route 16 Interchange Reevaluation	COMPARISON OF 2010 PM-PEAK-HOUR ASSIGNMENTS WITH FONSI-REPORT 2000 PEAK-HOUR VOLUMES	CTPS
Technical Report 61 August 1987		TABLE 3-3

constructing the Selected Alternative on the Ring Road and Salem Street is projected to be approximately -477 VPH during the PM peak hour (2010).

In fact, although the 2010 peak hour volumes are generally an order of magnitude higher than the FONSI report volumes, the anticipated impacts from the construction of connections "A" and "B" are confirmed by the comparison of locational volumes as presented in Table 3-3.

4 LEVEL OF SERVICE ANALYSIS

4.1 INTRODUCTION

Since 1980 when the I-93/Route 16 proposed improvements were first analyzed in detail, an updated (1985) version of the Highway Capacity Manual(HCM) has been released. The 1985 HCM differs from the earlier version in several respects, but most importantly from the perspective of this analysis in the parameters used to determine level of service. Previous HCM level of service analyses related service levels directly to the ratio of actual or forecast hourly volume to hourly capacity. In theory, as the proportion of the volume-to-capacity ratio approached (1.0) one, service levels declined from A to F, eventually failing under excessive demand levels.

The 1985 HCM level of service analysis focuses rather on defining a level of service according to the delay (in seconds) experienced by vehicles on a road segment or at an intersection. Capacity is also defined, but intersection capacity and delay estimates are derived in large part by the operating characteristics of the vehicles attempting to use the time and physical space of the intersection. As with previous capacity analysis methods, the 1985 HCM ranks performance from A to F where A represents the best possible operating conditions and F represents conditions characterized by excessive delay.

Although the formulations of level of service described above differ in basis, the A-to-F rankings can generally be expected to describe similar operating conditions. This point is made here to highlight the fact that the levels of service initially described in the 1980 "FONSI" Report were re-evaluated (reanalyzed) using the 1985 HCM techniques. The most recent analysis indicated many fewer instances of failure present under existing or future conditions in Medford Square and the surrounding area. This condition is related to the operating environment of the area and not by the use of a different analysis method.

4.2 ANALYSIS RESULTS

The level of service (LOS) analysis conducted for this study concentrated on the same intersection and local road segments analyzed for the 1980 "FONSI" Report. A summary of that analysis is presented in Table 4-1. Assumed for the purpose of this analysis is that the current geometric conditions will be maintained through the 2010 horizon. That is, the only changes to the system will be those specific to the construction of the proposed

	1990		2010	
	No-Build	Build	No-Build	Build
Ring Road at Riverside Street				
Riverside St. EB	B	B	B	B
Riverside St. WB	C	C	D	C
Ring Road NB	C	B	C	B
Intersection	C	B	C	B
Main Street (Rte. 60) at Forest Street and High Street (Medford Sq.)				
High St. EB	A	A	B	A
Main St. WB	B	A	B	A
Forest St. SB	C	C	C	C
Intersection	B	A	B	A
Fellsway (Rte. 28) at Fulton Street				
Fellsway EB	B	B	B	B
Fellsway WB	B	B	B	B
Fulton St. NB	B	B	C	B
Fulton St. SB	B	B	B	B
Intersection	B	B	B	B
Main Street at Route 16 EB Ramps				
Main St. left turn	F	D	F	D
Ramp left turn	F	F	F	F
Ramp right turn	A	A	A	A
Main Street at Route 16 WB Ramps				
Main St. left turn	E	D	E	D
Ramp left turn	F	F	F	F
Ramp right turn	A	A	A	A

ramp connections. In addition, it was assumed that under all scenarios, the timing and phasing of signals would be optimal for the traffic conditions forecast at each signalized intersection location. This assumption is important to the analysis and the interpretation of it in that it eliminates any spurious effects caused by conditions other than network alterations. The assumption may, however, contribute to the generally improved levels of service found throughout Medford Square in the current analysis when compared to that reported earlier in the "FONSI". It is not, however, likely that this assumption is responsible for major differences. Rather, the one-way system presently in operation in Medford Square has greatly improved traffic flow in the area and resolved the major operational problems that had existed in the Square prior to construction of the one-way Ring Road.

To understand the information presented in Table 4-1, one further point about the theory of 1985 HCM should be noted. The operational quality of a road segment, such as those selected for analysis in the FONSI, is considered in the new HCM to be a direct function of operations at the downstream intersection. The analysis results summarized in Table 4-1, therefore, indicate a LOS ranking by intersection approach that is roughly equivalent to the road segment capacity analysis performed for the FONSI.

At the signalized intersections of the Ring Road at Riverside Street, Main Street at Forest and High streets and the Fellsway at Fulton Street, vehicle operations are expected to perform acceptably (LOS C or better) throughout the forecast period under either scenario. The build option does, however, have the potential to improve operations in general as reflected in the improved LOS rankings.

The most notable improvement of the build scenario, among these three intersections, is the improved condition of the Riverside Street westbound approach where the level of service improves from D to C in 2010.

The analysis of the unsignalized Main Street at Route 16 intersections indicates that the build scenario will have a positive effect on intersection operations where Main Street left turns onto each of the ramps will function at LOS D; an improvement over the no-build scenario from F at the eastbound ramp and E at the westbound ramp. Left turn delays for traffic moving from the ramps onto Main Street are, however, expected to continue to be excessive throughout the forecast period whether or not the proposed connections are constructed.

To determine if a traffic management solution may exist that would resolve the problems at the Main Street/Route 16 ramps, each intersection was re-evaluated as a signalized location.

In general, signalizing each of the ramp intersections is not sufficient to address 1990 or 2010 traffic demands (refer to Table 4-2). Signalization alone, (again assuming optimal phasing and timing) would not provide sufficiently improved time allocation to critical movements to effect an elimination of excessive delays. However, the introduction of a signal in conjunction with the construction of the Selected Alternative proposal could improve operational levels of service for these intersections from F to B. This is due primarily to the improved ability of a signal to minimize average stopped delay through improved time allocation and in this case to better meet Main Street traffic demands at the ramp intersections during peak hour. This reduction in delay to the major street movements through the intersection results in a generally good operational level, where the side-street (ramp) delay is high, but relatively inconsequential due to the low traffic volume.

	1990		2010	
	No-Build	Build	No-Build	Build
Main Street at Route 16 EB Ramps				
Ramp EB	F	F	F	F
Main St. NB	A	A	A	A
Main St. SB	F	C	F	C
Intersection	F	B	F	B
Main Street at Route 16 WB Ramps				
Ramp WB	F	D	F	E
Main St. NB	F	B	F	B
Main St. SB	B	A	B	A
Intersection	F	B	F	B

I-93/Route 16 Interchange Reevaluation	LEVEL-OF-SERVICE ANALYSIS COMPARISON: PM PEAK HOUR MAIN ST. AT RTE. 16 EB & WB RAMPS (ASSUMING COORDINATED SIGNAL CONSTRUCTION)	CTPS
Technical Report 61 August 1987		TABLE 4-2

5 FINDINGS AND CONCLUSIONS

5.1 SUMMARY OF FINDINGS

The 1980 FONSI Report indicated that the proposed Urban Systems "Ring Road" project would not be included among the Medford Square highway network assumptions for which travel demand scenarios would be developed and analyzed to improve the Route I-93/Route 16 interchange connections. Since its release, Medford Square traffic conditions have been improved significantly by the changes in traffic patterns caused by the construction of the Ring Road project.

The re-evaluation of travel demands under a new 20-year time horizon, 1990-2010, indicated primarily that traffic volumes within the original "FONSI" study area are expected to be significantly higher in 1990 and 2010 than projected by the earlier work for the year 2000. A comparison of the current volume forecasts with the previous volumes indicates that the one-way system in Medford Square has resulted in a distribution of volumes which effects a lower volume on individual street segments although total traffic in the Square is now projected at higher levels. I-93 and Route 16 traffic volumes are also expected to be well above the previous future-year 2000 levels discussed in the FONSI Report.

Construction of the Selected Alternative is expected to divert approximately the same volume of peak hour traffic to Connection "A" (I-93 southbound to Route 16 westbound) as projected in the FONSI; approximately 410 VPH. The Connection "B" ramp, however, is currently projected to carry more volume than projected by the FONSI (approximately 750 VHP vs. 550 VPH). The volume diverted to Connection "A" is traffic that uses Medford Square to make the connection between I-93 southbound and Route 16 westbound. That diverted to the Connection "B" on-ramp is largely traffic currently using Route 28 (the Fellsway) to reach I-93 north.

The level of service analysis indicates that the Ring Road project has greatly improved traffic operations in Medford Square and that the proposed improvements serve a more limited function in resolving local traffic problems than would have been the case had the Ring Road not been constructed. Nevertheless, the provision of the proposed I-93/Route 16 connections are expected to measurably upgrade the level of service throughout Medford Square. Particularly important improvements in service levels are expected on:

- o the Riverside Street westbound approach to the Ring Road; and

- o Main Street at the Route 16 eastbound and westbound ramps.

5.2 SUMMARY OF CONCLUSIONS

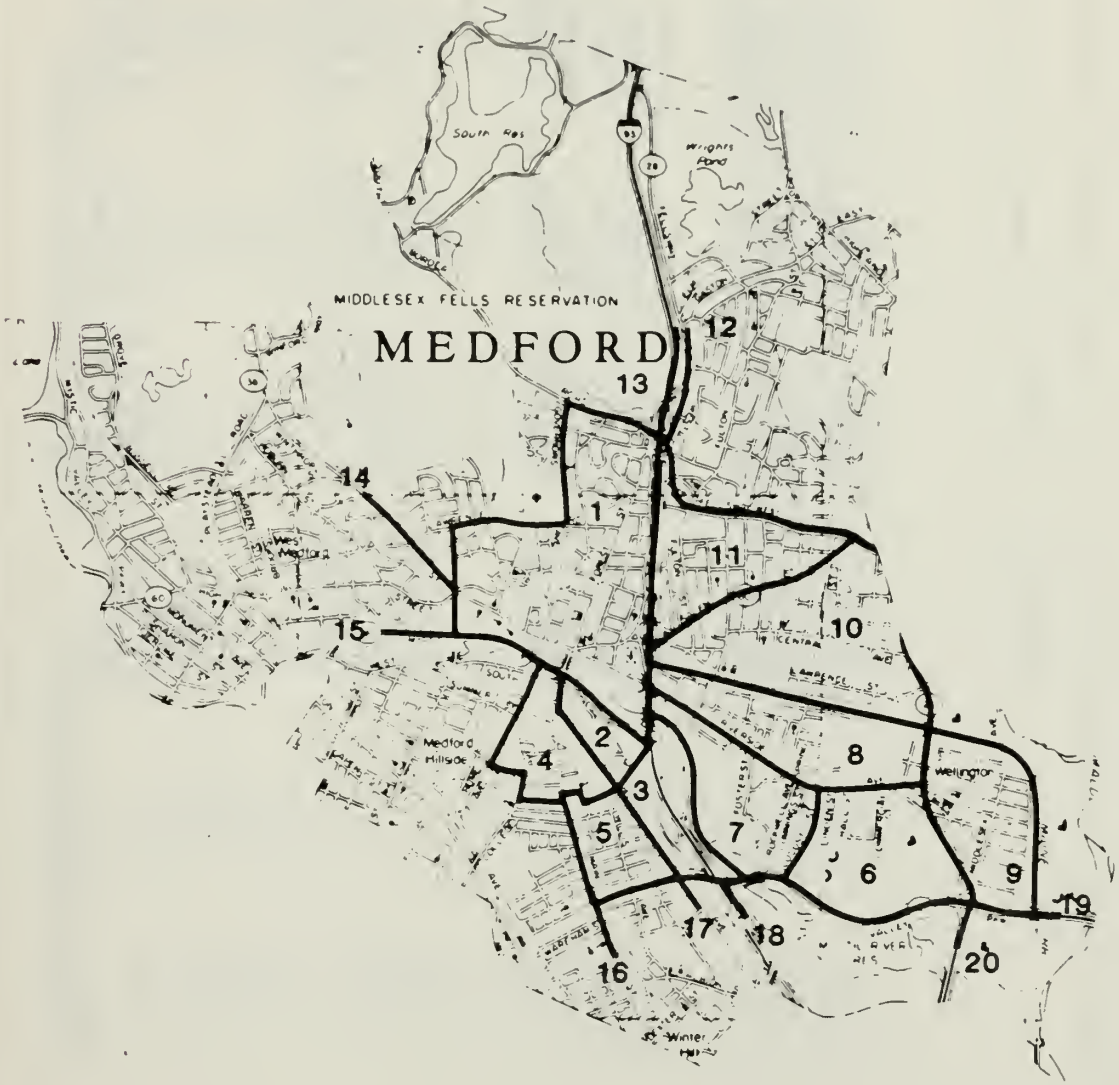
Evaluation of the proposed I-93/Route 16 interchange improvements under a new 20-year horizon from 1990 to 2010 and including the effects of recent traffic circulation improvements in Medford Square, indicates that the proposed improvements will have similar traffic diversionary impacts to those initially discussed in the 1980 FONSI report. The construction of Connection "A" linking I-93 southbound to Route 16 westbound will divert traffic from Medford Square (presently the most direct means of access) back onto the highway and new ramp. The construction of Connection "B" to link westbound Route 16 with northbound I-93 will have a slightly stronger diversionary effect than originally anticipated by capturing a significant volume from Route 28 northbound traffic between Route 16 and I-93 and a lesser additional volume presently using Medford Square to connect with I-93 northbound.

These effects continue to be of benefit to travel conditions in Medford Square as indicated by a level of service analysis that showed rankings generally improved by a grade level with the proposed project in place. The need for the project is, however, less urgent from the perspective of traffic operations in Medford Square due to the effect of improvements already in place. The proposal does, nevertheless, have substantial traffic operations improvement potential if implemented in conjunction with signalization upgrades at the Main Street/Route 16 ramp intersection south of the Square.

APPENDIX A

STUDY AREA
SOCIO-ECONOMIC BASE DATA
AND FORECASTS

(1987, 1990, 2010)



I-93/Route 16 Interchange Reevaluation	STUDY AREA TRAFFIC ZONE MAP	CTPS
Technical Report 61 August 1987		FIGURE A-1

Traffic Zone	Median Income 1980 $'s	Households 1987	1990	2010
1	18,266	1,843	1,842	1,840
2	18,266	228	228	228
3	18,266	476	476	476
4	18,266	247	247	247
5	18,266	957	958	957
6	18,266	0	0	0
7	18,266	714	714	714
8	18,266	715	715	715
9	18,266	714	714	714
10	18,266	1,937	1,936	1,934
11	18,266	865	865	864
12	23,562	5,620	5,723	5,845
13	23,995	7,406	7,554	7,716
14	25,836	7,708	7,874	7,983
15	20,836	17,619	17,209	17,220
16	15,066	71,942	71,836	71,810
17	16,480	63,356	63,359	63,374
18	16,480	63,356	63,359	63,374
19	15,258	10,345	10,369	10,428
20	16,480	63,356	63,359	63,374

Traffic Zone	Retail Employment			Non-Retail Employment		
	1987	1990	2010	1987	1990	2010
1	984	1,003	1,028	2,793	2,786	2,782
2	113	115	120	314	320	326
3	182	186	191	519	519	520
4	122	124	130	341	346	353
5	366	374	383	1,042	1,043	1,045
6	683	696	733	0	0	0
7	227	-	-	636	647	661
8	228	-	-	637	648	662
9	227	-	-	636	647	661
10	267	273	282	758	762	769
11	238	242	246	674	673	674
12	1,420	1,482	1,759	4,094	4,070	5,553
13	2,809	3,271	3,624	10,317	10,130	13,401
14	2,014	2,419	2,618	13,505	13,467	15,886
15	5,216	5,370	6,885	25,404	25,521	30,891
16	22,164	22,142	22,066	166,623	168,514	190,656
17	19,527	19,633	21,581	146,874	148,404	168,037
18	19,527	19,633	21,581	146,874	148,404	168,037
19	1,686	1,688	1,684	6,861	6,886	8,573
20	19,527	19,633	21,581	146,874	148,404	168,037

APPENDIX B

24-HOUR VOLUME SUMMARIES
NO-BUILD AND BUILD SCENARIOS

(1987, 1990, 2010)

APPENDIX B

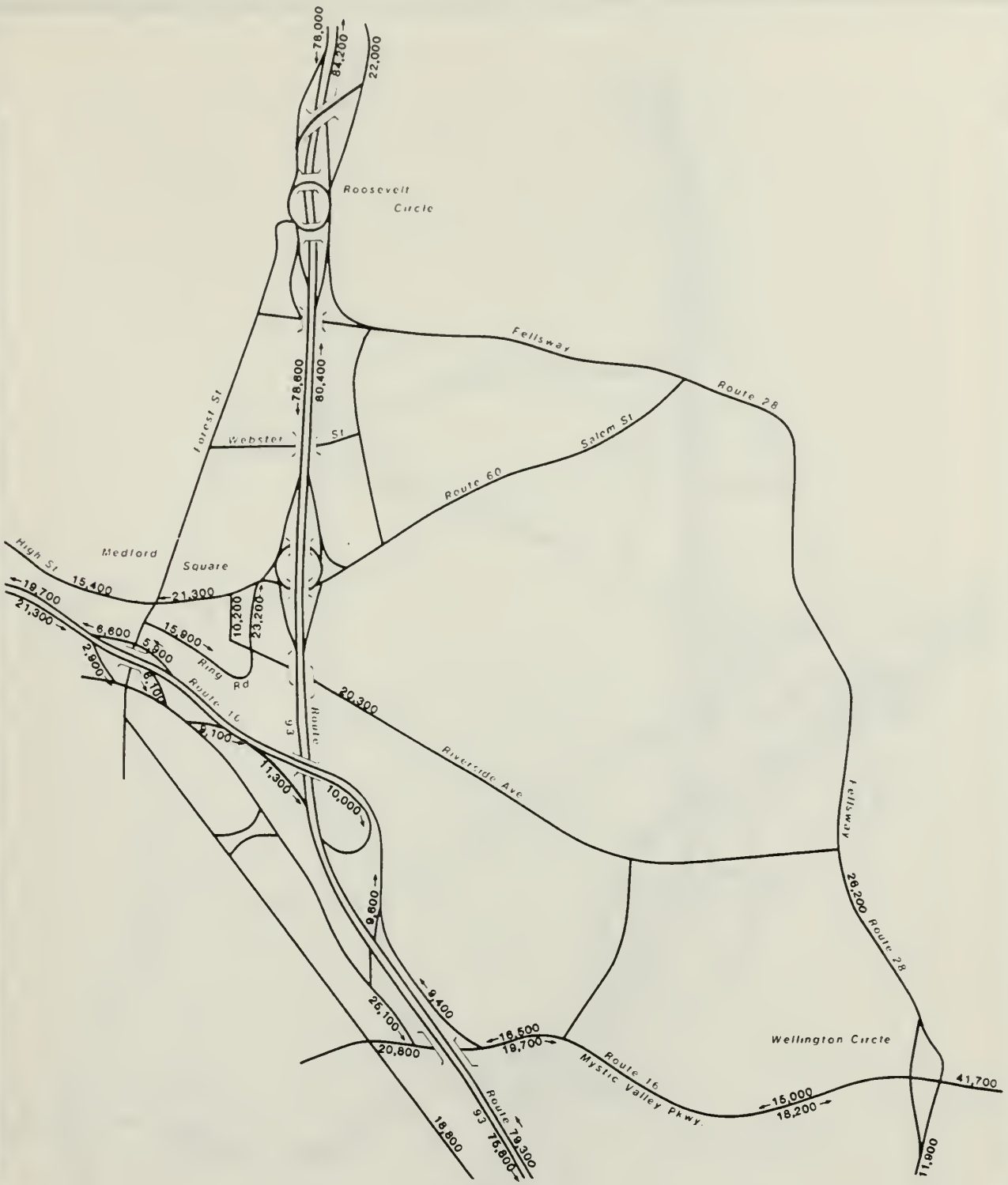
24-HOUR VOLUME SUMMARIES
NO-BUILD AND BUILD SCENARIOS

(1987, 1990, 2010)

The information presented in Appendix B complements the AM and PM peak-hour volume assignment information presented in the text. No-Build and Build 24-hour assignments were prepared for the baseline (1987) and future-year (1990 and 2010) periods.

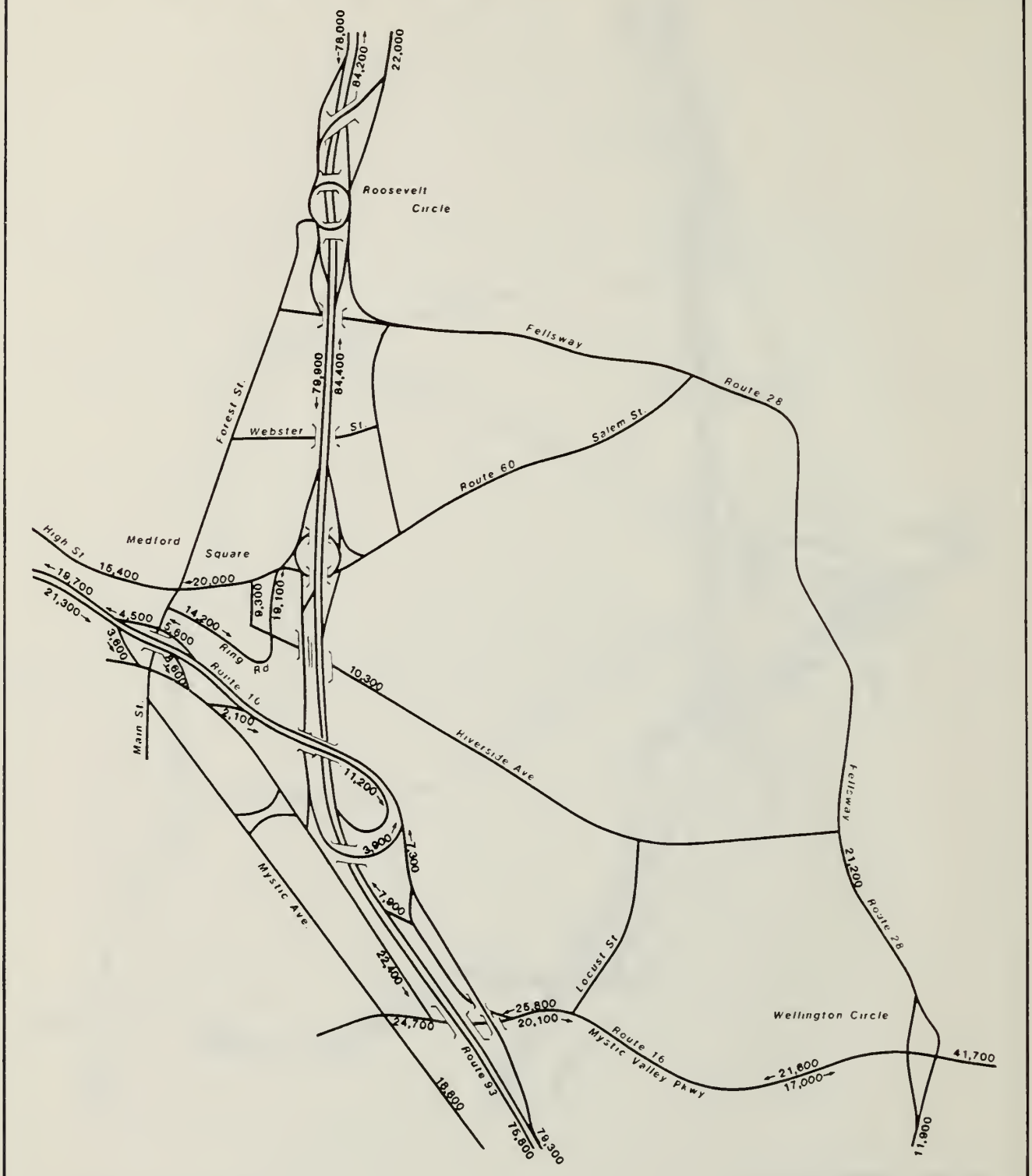
The results are presented on the schematic maps used in the report. The locations selected again represent those considered important in the original work as well as those which are now important.

In addition, Table B-2 (a comparison of FONSI future-year 2000 and "Reevaluation Study" future-year 2010) has been included in Appendix B. Examination of the table indicates that the findings drawn in the report regarding the same comparison of PM peak-hour forecasts apply to the 24-hour results. In summary, the presence of the Ring Road has caused a redistribution of traffic volumes within the downtown that is indicated by lower volume levels on certain segments; significantly higher volumes in the study area overall as indicated by I-93 volume totals; and similar levels of Connection "A" and "B" usage as were originally reported.



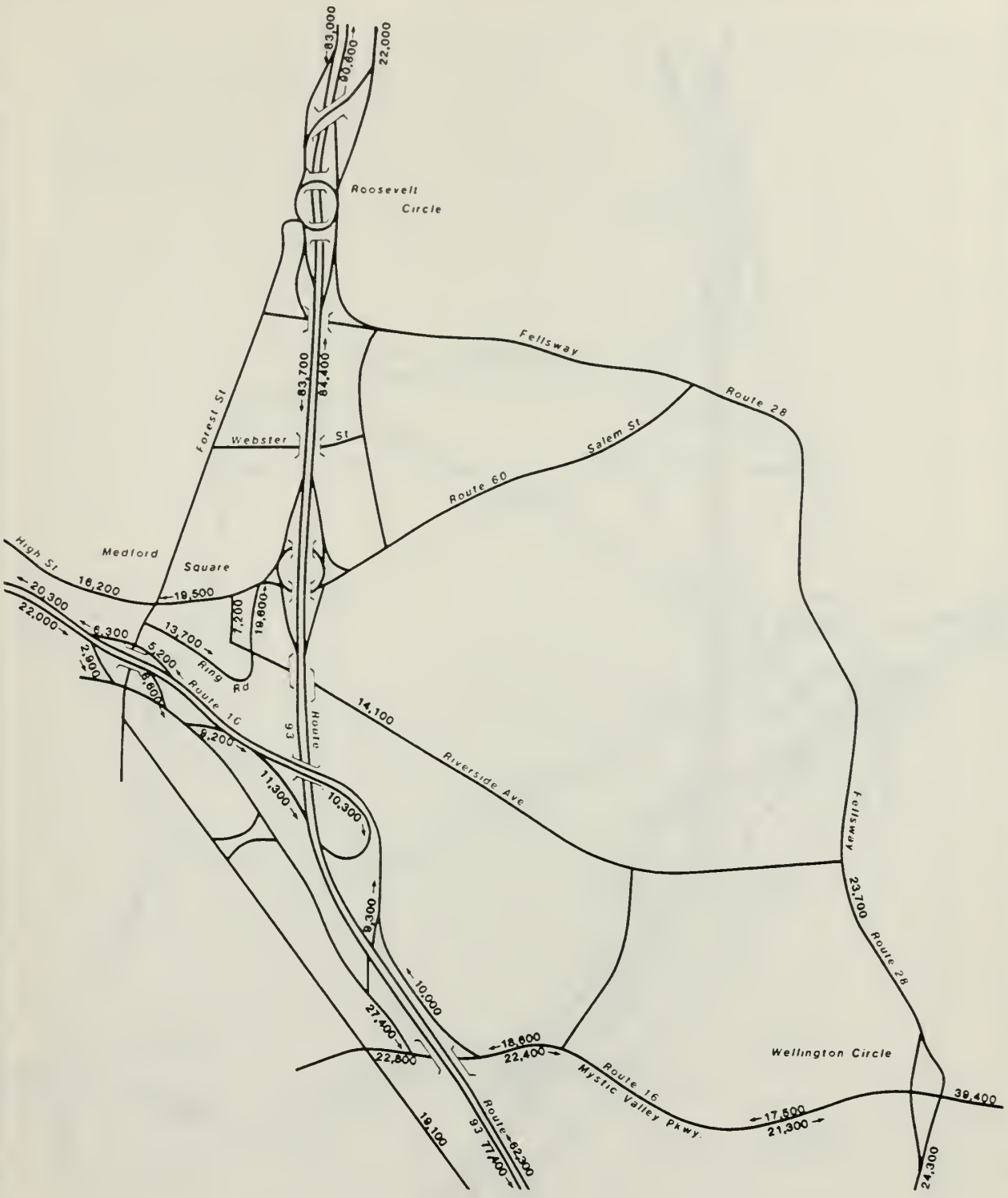
All Numbers listed with no arrows are TWO Directional Volumes

I-93/Route 16 Interchange Reevaluation	1987 24-HOUR "NO BUILD" ALTERNATIVE TRAFFIC ASSIGNMENT	CTPS
Technical Report 61 August 1987		FIGURE B-1



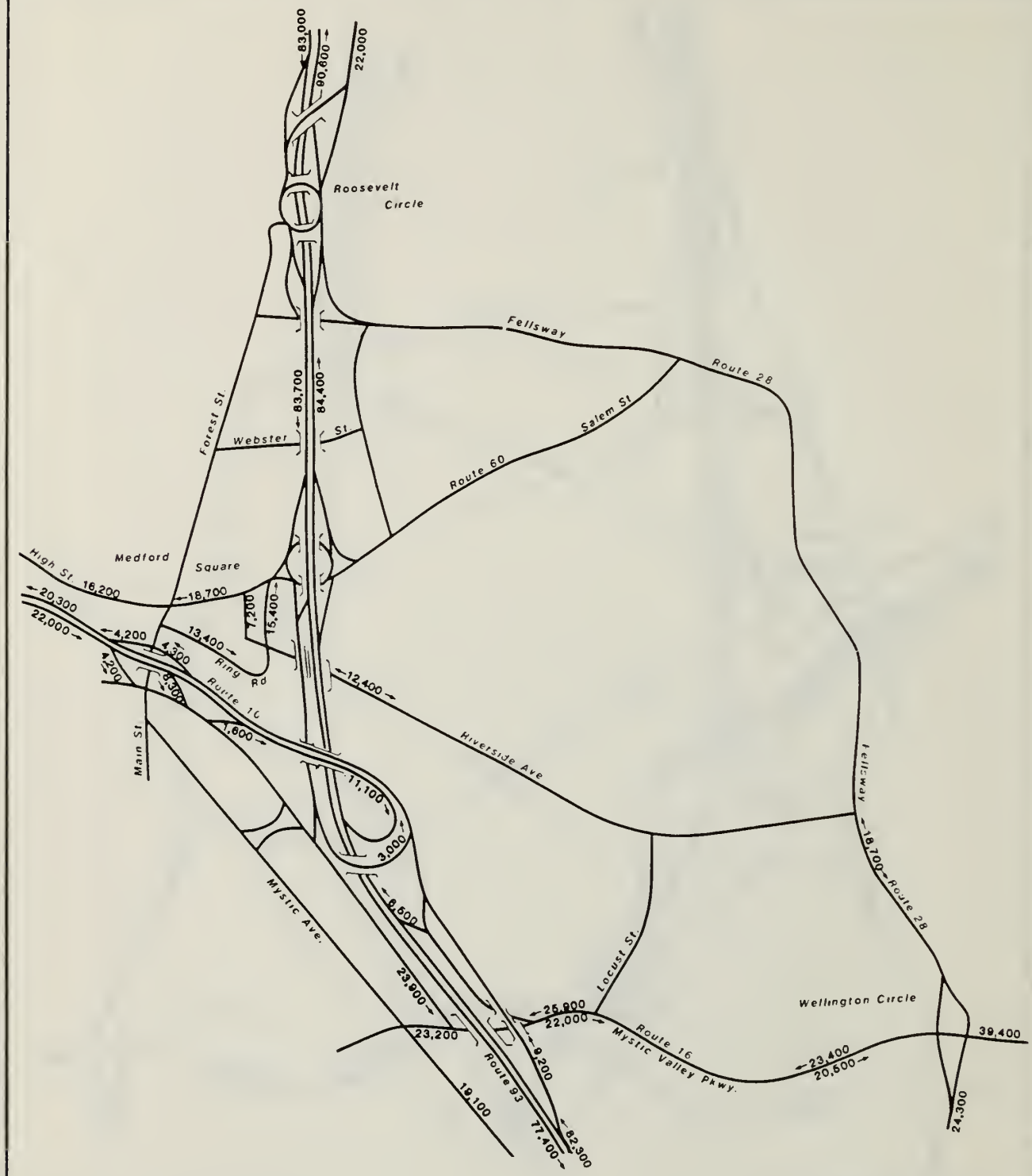
All Numbers listed with no arrows are TWO Directional Volumes

I-93/Route 16 Interchange Reevaluation	1987 24-HOUR "BUILD" ALTERNATIVE TRAFFIC ASSIGNMENTS	CTPS
Technical Report 61 August 1987		FIGURE B-2

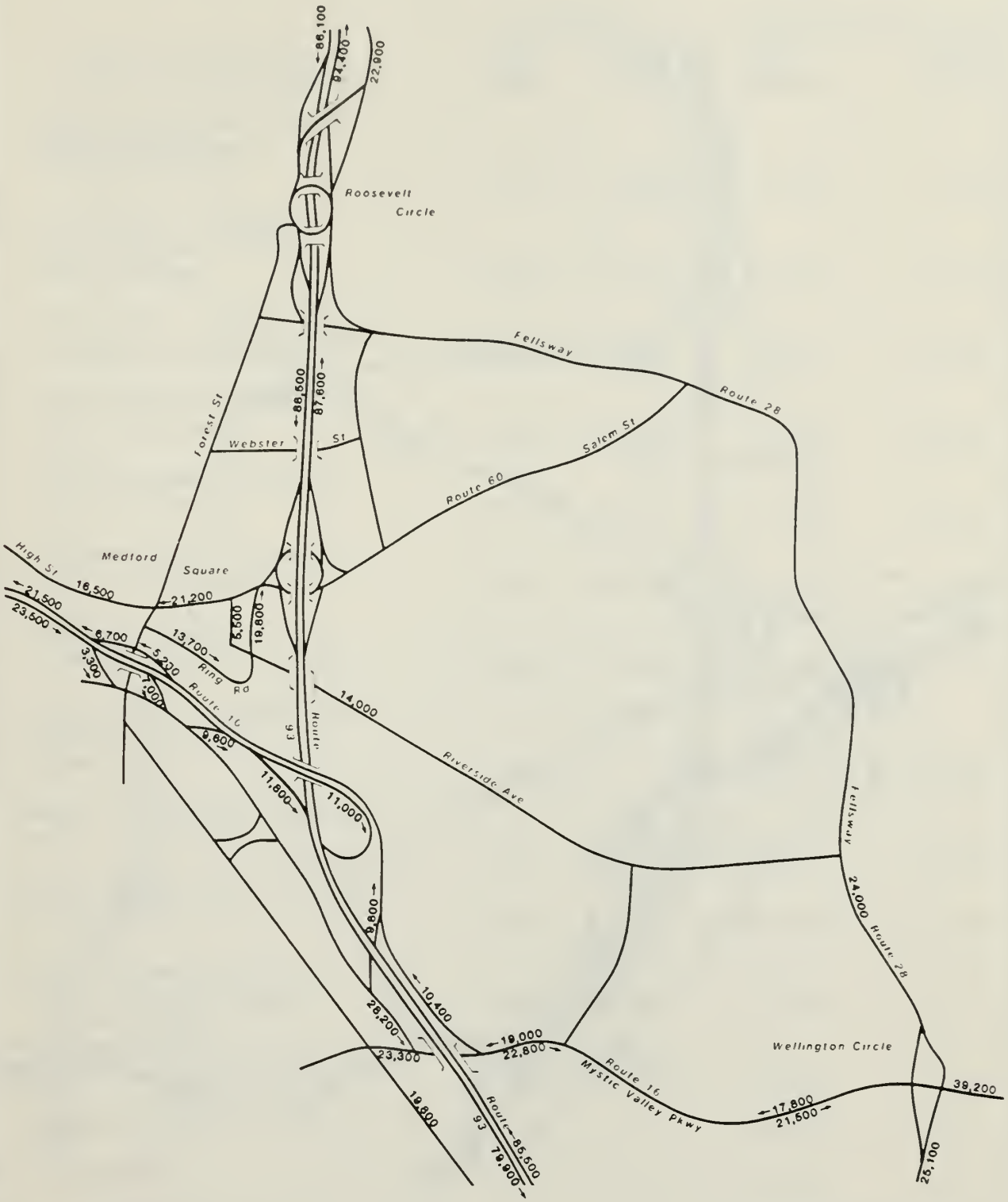


All Numbers listed with no arrows are TWO Directional Volumes

I-93/Route 16 Interchange Reevaluation	1990 24-HOUR "NO BUILD" ALTERNATIVE TRAFFIC ASSIGNMENTS	CTPS
Technical Report 61 August 1987		FIGURE B-3

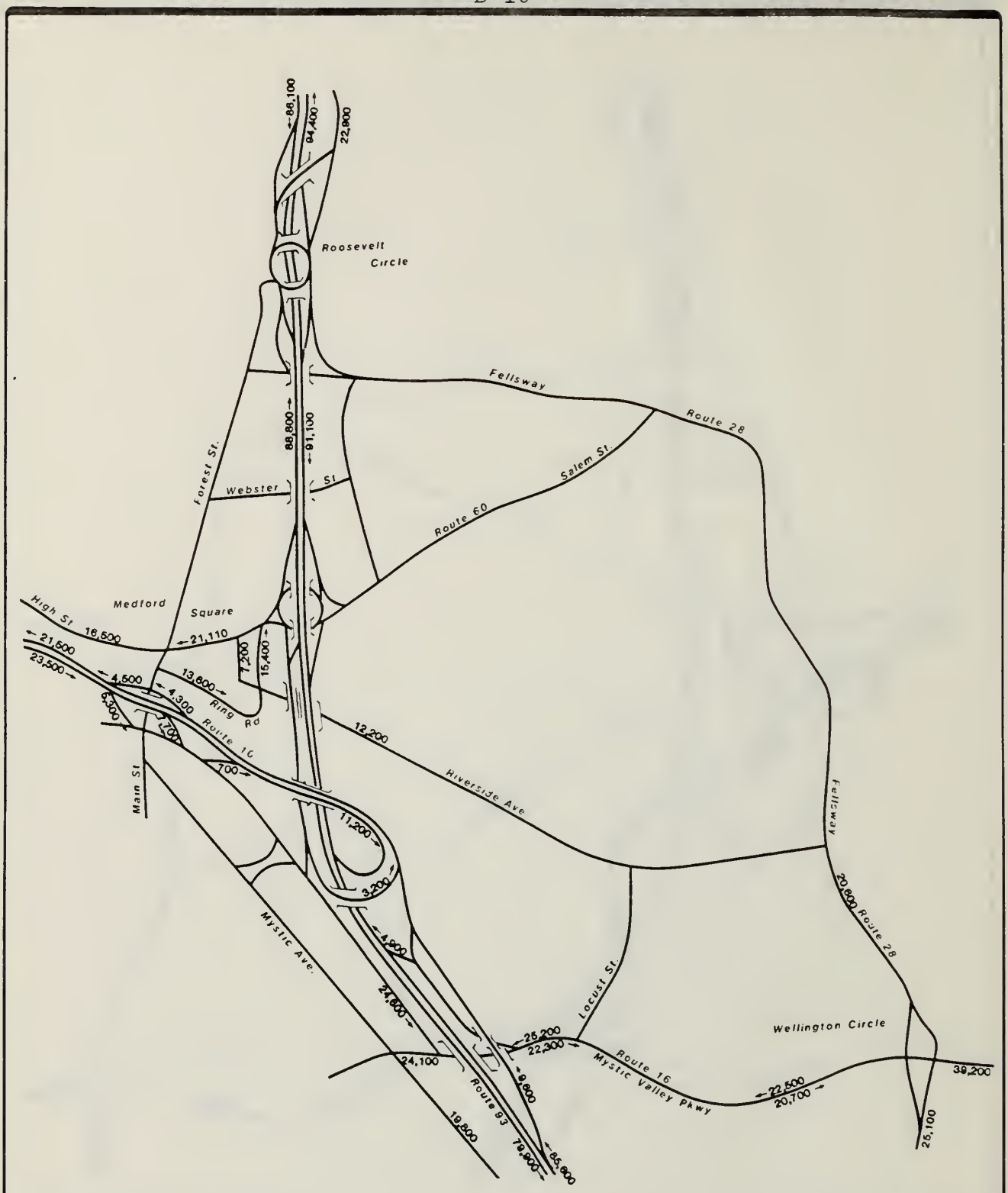


I-93/Route 16 Interchange Reevaluation	1990 24-HOUR "BUILD" ALTERNATIVE TRAFFIC ASSIGNMENTS	CTPS
Technical Report 61 August 1987		FIGURE B-4



All Numbers listed with no arrows are TWO Directional Volumes

I-93/Route 16 Interchange Reevaluation	2010 24-HOUR "NO BUILD" ALTERNATIVE TRAFFIC ASSIGNMENT	CTPS
Technical Report 61 August 1987		FIGURE B-5



I-93/Route 16 Interchange Reevaluation Technical Report 61 August 1987	2010 24-HOUR "BUILD" ALTERNATIVE TRAFFIC ASSIGNMENTS	CTPS FIGURE B-6

Location Description	No-Build 2000 FONSI	No-Build Current 2010	Selected Alternative 2000 FONSI	Selected Alternative Current 2010
Riverside Avenue, between Medford Square and City Hall Avenue	27,300	5,500	27,300	7,200
Salem Street, between City Hall Avenue and Medford Square	28,000	21,200	22,500	21,100
Main Street, Medford Square to Route 16 west ramps	32,500	30,800	27,000	26,200
I-93 northbound, north of Route 38 on-ramp	56,900	85,500	47,200	85,500
I-93 southbound, north of Route 38 on-ramp	45,300	79,900	45,300	79,900
I-93 northbound, south of Route 60 off-ramp	53,600	86,900	59,500	92,100
I-93 southbound, south of Route 60 on-ramp	47,100	81,500		
I-93 southbound, south of proposed exit for Connection A			31,100	63,500
Route 16 eastbound, west of Main Street	24,200	23,500	24,200	23,500
Route 16 westbound, west of Main Street	28,200	21,500	28,200	21,500
Route 16, east of I-93 (Gen. Lawrence Bridge)	41,900	41,800	47,000	47,500
Middlesex Fells Parkway, east of I-93 (Fulton St.)	20,400	28,700	15,100	26,200
Connection A			5,500	3,200
Connection B			5,300	4,900